

**Senator George J. Mitchell Center
Annual Technical Report
FY 2017**

Introduction

Maine is fortunate in being a water-rich state with extensive surface water and groundwater resources. These water resources are essential to the regional economy in terms of energy generation, water supply, agriculture, tourism, industry, and ecosystem services. The state is not without water resource concerns due to flooding, sea-level rise, urbanization, storm water, endangered aquatic species, harsh winters, and natural contaminants such as arsenic in drinking water. The Maine Water Resources Research Institute (WRRI) is the primary independent source of water resources research in the state. Situated in the Senator George J. Mitchell Center for Sustainability Solutions (Mitchell Center), our approach to water resources research necessarily focuses on intersecting environmental, social and economic issues. Our mission is to serve as a leader and valued partner in understanding and solving societal problems related to the growing challenge of improving human well-being while protecting the environment.

During the FY17 period, the Maine WRRI supported four research projects: 1) Improved delineation and analysis of flood attenuation in Maine's watersheds: natural infrastructure support of the state of Maine's Clean Water Initiative (Chapter 589); 2) Real time data for Sebago Lake to support sustainable water resource management, lake research, undergraduate research training, and community engagement; 3) Contamination of Messalonskee Lake by pharmaceuticals and chemical ingredients in personal care products: an emerging ecological and public health threat; and 4) Maine's changing winter: focus on natural resources, ecology, and the economy. Two other projects continued in FY17 under no-cost extensions: 1) Assessing the vulnerability of Maine's drinking water resources to extreme precipitation events and; 2) Vernal pools for me (information transfer). The Maine WRRI also supported information transfer activities including the Maine Sustainability and Water Conference, the Mitchell Lecture on Sustainability, and a weekly speaker series. Active projects directly supported three graduate students (2 Ph.D., 1 M.S.), three undergraduate students, and one postdoctoral researcher.

The federally authorized Maine WRRI provides fundamental and essential functions, which would not exist without explicit Congressional re-authorization and appropriations. The federal money that supports the Maine WRRI is highly leveraged with funds provided by other granting agencies, stakeholders, universities, and researchers. We issue an annual request for proposals and use a peer-review process involving a wide range of disciplinary expertise to identify the most scientifically rigorous projects that also align with the WRRI program's mission, vision and objectives. The WRRI Director also consults with members of the Research Advisory Committee comprised of representatives from the Mitchell Center, the USGS New England Water Science Center, and other relevant experts to make final award selections.

The Maine WRRI Director David Hart serves as the Director of the Mitchell Center which provides the administrative home for the Maine WRRI and helps increase the breadth and accessibility of water resources research in Maine.

In 2009, the Mitchell Center was the recipient of a five-year, \$20 million grant from the National Science Foundation to support the Sustainability Solutions Initiative. This grant fostered a multi-institutional interdisciplinary research network across the state that continues to create collaborative research opportunities for faculty and students focused on a wide range of sustainability challenges involving water resources. It also led to the creation in 2014 of a permanent, state-wide research program, the Senator George J. Mitchell Center for Sustainability Solutions. The Mitchell Center subsequently received two \$6 million NSF grants focused on water resource issues. The first project, "Strengthening the scientific basis for decision-making: Advancing sustainability science and knowledge-action capacities in coupled coastal systems", focuses on water quality and public health issues associated with the run-off of fecal-borne pathogens that pose risks to shellfish beds and beach use. Begun as a collaboration with the University of New Hampshire and four other institutions in Maine and New Hampshire, the project is continuing with a wide range of funding. Several decision-support

tools have already been developed to meet the needs of state resource agencies, and our current research is growing the capacity of decision-makers to respond more effectively to threats associated with coastal pollution. The second NSF grant, “Strengthening the scientific basis for making decisions about dams: Multi-scale, coupled-systems research on ecological, social, and economic trade-offs,” includes five partner institutions, including the University of New Hampshire, University of Rhode Island, and Rhode Island School of Design. The team of 25 faculty, 2 postdoctoral fellows, and 25 graduate students conducts stakeholder-engaged, solutions-driven, interdisciplinary research to examine the complex tradeoffs associated with alternative management decisions about dams (e.g. relicensing hydropower dams, removing obsolete dams, enhancing fish passage). Drawing from diverse disciplines, the team uses a wide range of innovative tools (e.g. fish survival analysis, production possibility frontiers, dam failure risk assessment, multi-criteria decision analysis, biogeochemical budgets, negotiation simulation, media discourse analysis, participatory systems dynamic modeling) to develop decision-support tools for government, the private sector, and non-governmental organizations.

Separate from our WRRI funding, the Mitchell Center also provides annual seed funding for sustainability projects based on a competitive, peer-reviewed process. One currently funded water resource-linked project is looking at overcoming institutional barriers to the recovery of Atlantic salmon by navigating the social-science/policy interface. The project team contends that evaluation of interactions among entities (NOAA, FWS, and others) in the face of uncertainty may inform the processes by which recovery policies and actions are made. A second research project is looking at ocean and coastal acidification which presents a unique set of chronic sustainability challenges at the human-ecological interface along the coast of Maine. Recent evidence makes it clear that local-scale factors are also important in ocean and coastal acidification including low alkalinity river runoff and excessive nutrients in water bodies. Maine is particularly vulnerable because of its position in the Gulf of Maine, which has a lot of freshwater inflow. This project is helping to establish standardized coastal acidification monitoring efforts with volunteer citizen scientists at its core.

Another FY17 water resource-related projects include development of a workshop in collaboration with the Maine Dept. of Transportation on Habitat Connectivity Design for fish passage through transportation hydraulic structures. UMaine associate professor Sean Smith developed and taught the workshop. Smith, an expert in watershed science and management, has a joint faculty position with the Mitchell Center and the School of Earth & Climate Sciences.

Former Maine WRRI Co-Director John Peckenham collaborated with the Maine Drinking Water Program (DWP) on a project looking at the occurrence and potential for harmful algae blooms in public drinking water supplies in Maine. Peckenham completed a report to Maine DWP in May 2017. Two of the major issues addressed in the report were the lack of knowledge about harmful algae blooms among smaller utility districts in Maine and a lack of water quality testing beyond the state requirements. Report recommendations included: 1) implementation of basic, low-cost water quality testing to indicate potential conditions for algae growth (recommendation made in collaboration with the Maine Dept. of Environmental Protection); 2) use of external monitors (volunteers, citizen scientists) to assist smaller districts with water quality sampling; and 3) education of utility managers on harmful algae focused on the interactions between activity in the watershed, water quality conditions, cyanobacteria ecology, and the effects of cyanobacteria on treatment processes.

The National Science Foundation awarded a one-year grant to continue a citizen science project aimed at protecting lake water quality in Maine. The grant helps extend a project begun in 2015, with funding from the Mitchell Center, into 2018 and beyond. Collaborators include monitors from the Maine Volunteer Lake Monitoring Program, homeowners and lake associations on lake stewardship activities, and the Maine Dept. of Environmental Protection. The project is led by Aria Amirbahman, UMaine professor of civil and environmental engineering who is also a fellow in the Mitchell Center. He is collaborating with Firooza Pavri, director of the University of Southern Maine’s Muskie School of Public Service, a geographer who conducts the social science component of the work. The interdisciplinary project focuses on 24 Maine lakes and is

developing a “Lake Vulnerability Index” through an innovative integration of biophysical and social science methods. The Index is meant to be a means of predicting which lakes are more susceptible to deterioration in water quality via chemical, physical, and biological measurements and identifying—through surveys and interviews—the underlying factors that encourage the kinds of citizen science collaborations that result in more effective protection of lake water quality. When fully developed, the Vulnerability Index will provide scientists, regulators, and concerned citizens with more effective strategies for the stewardship of Maine lakes.

Another Mitchell Center fellow, Adam Daigneault, is contributing to an innovative research project designed to develop more effective strategies for protecting water quality in Sebago Lake, the source of drinking water for more than 200,000 Maine residents. The Sebago Water Fund, a collaboration of eight organizations including The Nature Conservancy and the Portland Water District, seeks to protect water quality, community well-being, and the health of fish and wildlife in the Sebago Lake watershed through voluntary forestland protection. The 282,000-acre watershed provides drinking water to nearly one-sixth of the State’s population, sustains a booming local recreation and fishing economy, and supports local businesses including a thriving brewing industry. The group is providing funding to Daigneault, Assistant Professor of Forest, Conservation and Recreation Policy, along with his colleague, Aaron Strong, Assistant Professor of Marine Policy. Together, they are assessing the economic contributions of clean water, intact forests, and land protection in the Sebago Lake watershed to the people of Maine. The project has a drinking water focus, but also includes co-benefits, such as recreation, public health, carbon sequestration, fish and wildlife habitat, and agriculture and timber production. The collaborative anticipates that an economic case for watershed protection will rely on the values from co-benefits rather than stand on water quality alone.

The annual Maine Sustainability & Water Conference continues to be the leading state event for water resources researchers and stakeholders. Research supported by the Maine WRRI is prominently featured at the conference. The number of people and organizations who support and contribute to the conference reflects the importance of water in the state. Through the hard work of Mitchell Center staff, the Conference Steering Committee, and other key supporters, we are able to address the important water issues in Maine and to bring together a wide range of stakeholder groups representing the public and private sectors, academic institutions, and non-governmental organizations. Steering Committee members include representatives from federal and state government, NGOs, the private sector, and academic institutions. The conference schedule provides ample time for networking; an important resource for participants working in a large and diverse rural state.

Research Program Introduction

The Maine WRRI supports research, information transfer projects, and seed grants using Section 104b funds. Grants funded under Section 104b deal with important aspects of Maine's highly-valued water resources. Projects are awarded on a competitive basis using a two-stage selection process.

The Maine WRRI issued a call for pre-proposals in spring 2016. Seven pre-proposals were received and were initially reviewed by a panel of relevant experts. Based on this review, all seven of the investigators were invited to submit full proposals. Shortly after this decision was made, one of the proposals was withdrawn. Six full proposals were received in fall 2016 and were reviewed by the same panel of relevant experts. Reviewers assessed the proposals for relevance to the program's mission, vision and objectives. The WRRI Director consulted with members of the Research Advisory Committee to make final award decisions. Four of the submitted full proposals were selected to receive funding. Two of these proposals are led by researchers at private undergraduate colleges (St. Joseph's College and Colby College).

Preference is given to support innovative projects that focus on the sustainability of Maine's water resources with research that is interdisciplinary, stakeholder-engaged, and solutions-driven. We also strongly encourage projects that are led by early career faculty, have significant student involvement, and involve researchers at small colleges and universities across the state. Investigators are encouraged to collaborate with state and federal agencies and to seek additional contributions for their projects.

Assessing the Vulnerability of Maine's Drinking Water Resources to Extreme Precipitation Events

Basic Information

Title:	Assessing the Vulnerability of Maine's Drinking Water Resources to Extreme Precipitation Events
Project Number:	2016ME319B
Start Date:	3/1/2016
End Date:	9/30/2017
Funding Source:	104B
Congressional District:	2
Research Category:	Climate and Hydrologic Processes
Focus Categories:	Climatological Processes, Ecology, Economics
Descriptors:	None
Principal Investigators:	Jasmine Saros

Publications

1. Warner, K.A., Saros, J.E., and Teisl, M.F. Investigating the ecological response and economic vulnerability of Maine's drinking water resources to extreme precipitation events. Poster presentation. Maine Sustainability and Water Conference, March 30, 2017, Augusta, Maine
2. Saros, Jasmine; Kathryn Warner, Mario Teisl, 2017, Assessing the Vulnerability of Maine's Drinking Water Resources to Extreme Precipitation Events, Maine Water Resources Research Institute, University of Maine, Orono, Maine, 6pp.

USGS 104b (WRII) Investigator Final Report

Project Title: Assessing the Vulnerability of Maine's Drinking Water Resources to Extreme Precipitation Events

Principal Investigator: Dr. Jasmine Saros, Climate Change Institute, University of Maine, 137 Sawyer Research Center, Orono, ME, 04469; 207-581-2112; jasmine.saros@maine.edu

Co-Project Investigator: Dr. Mario Teisl, School of Economics, University of Maine, 207 Winslow Hall, Orono, ME, 04469; 207-581-3162; teisl@maine.edu

Graduate Student Investigator: Kathryn Warner

1. Project Summary

The Northeastern U.S. has experienced a 60-70% increase in extreme precipitation events since 1950 (Madsen and Figdor 2007; Spierre et al. 2010), which may have important implications for the Maine's water quality. Lakes are an integral part of Maine's landscapes and communities, and approximately half of the high quality drinking water in Maine comes from 46 lakes across the state. DOC concentrations are expected to increase in boreal lakes by as much as 65% as a result of climate change (Larson et al. 2011), and recent research suggests that average annual concentrations of dissolved organic carbon (DOC) increased in Maine lakes during extreme wet years (Strock et al. 2016). This could have harmful effects on the chemical and biological quality of Maine's drinking water lakes. However, the extent to which storm events are altering DOC and consequently the biota of Maine lakes and the economic costs associated with these potential water quality changes is unclear. Thus it is difficult to determine whether management strategies will need to be modified to sustain drinking water quality.

Scientists and water district managers in Maine have already identified algal blooms, taste and odor problems, and harmful by-products as some of the problems caused by increased DOC concentrations. Increases in DOC from extreme precipitation events threatens aquatic habitats and drinking water quality, which will increase water treatment costs, and impose other economic losses (lost property tax revenues, lost economic activity) on communities, therefore understanding the ecological and economic implications are critical. Local stakeholders, particularly water treatment managers, have identified that DOC is a growing concern. For example, in the recent past, algal blooms have occurred in Chases Pond in York, ME following extreme rain events. The York Water District speculates that these blooms are a result of increased DOC from rain events. Additional water districts have also observed increased algae and have expressed concern about changes in DOC due to the relationship with disinfection by-products. Participating water utilities in this study have been instrumental to the success of this project and have welcomed the study of extreme rain events and DOC to better understand the ecological and economic implications.

Impaired drinking water quality, weakened aquatic habitats, and a loss of lake aesthetics may have significant negative impacts not only on the lakes, but communities relying on these lakes for drinking water, recreation, and tourism. Research conducted for this project, and the

collaborations with local stakeholders have identified how a subset of Maine lakes are responding to storm events and the implications on the quality of the water and subsequent water treatment costs is being evaluated. This research has allowed us to assess the vulnerability of drinking water sources to extreme precipitation events and enables us to evaluate future vulnerability of additional Maine drinking water sources.

2. Problem and Research Objectives

Increases in DOC from extreme precipitation events have several implications for drinking water quality. Increases in DOC correlate to increases in disinfection by-products (DBPs) (Van Leeuwen et al. 2005; Uyak and Toroz 2007). Additionally, DBPs and increased levels of complexed heavy metals and adsorbed organic pollutants are all problems created by a rise in DOC concentrations in drinking water (Matilainen 2010). DOC also provides carbon sources to mixotrophic algae, including chrysophytes. Some chrysophyte algal blooms contribute to taste and odor problems in drinking water sources (Nicholls and Gerrath 1985; Nicholls 1995). Several drinking water utilities are expressing concern from these implications.

Several drinking water utilities are beginning to realize and understand the relationship between changing DOC and DBP concentrations (Zhang et al. 2008; Bond et al. 2014; Ritson et al. 2014). Drinking water resources exempt from filtration are beginning to understand with more frequent storms and subsequent increased DOC in aquatic ecosystems, this exemption from filtration may change and could pose high economic costs. For drinking water resources that are required to filter, alteration to existing filtration could also result in high economic costs. Overall, these costs are not well documented but pose expensive remediation strategies. Since permitting, financing, and construction take time, understanding the pace of this growing threat helps communities make better water management decisions.

In order to understand the extent that extreme precipitation events are affecting Maine's drinking water lakes requires better understanding of the effects of individual storm events on these water resources. Currently, we lack the high temporal resolution data needed to better understand the scope of the problem in Maine. The overall objective of our research was to assess the ecological and economic vulnerability of Maine's drinking water lakes and the communities dependent on these resources to extreme precipitation events and subsequent increases in DOC. Specific objectives included:

- 1.) quantifying immediate changes in drinking water lakes from extreme precipitation events through measurement of key water quality metrics (DOC quantity, DOC quality, nutrients, algal biomass and community structure) pre- and post-storm;
- 2.) translating the above changes in water quality into economic losses, primarily the costs to maintain drinking water quality through filtration and/or treatment infrastructure.

3. Methodology

Six Maine drinking water lakes were selected to evaluate the influence of 5 extreme precipitation events and subsequent changes in DOC concentration and quality, additional water quality metrics, and changes in phytoplankton. Standard field and laboratory methods were used to

investigate lake water quality. Cost and valuation economics are being used to translate changes in water quality into potential costs to maintain drinking water quality. This project has been and will continue to be conducted by PhD student Kathryn Warner.

Lakes were selected based on morphometric and initial baseline chemical data as well as location, demographics and size of population served. The representative 6 lakes are distributed across the state of Maine to account for differences in climate and precipitation across the state. Variation in lake size and volume across the 6 lakes has allowed us to investigate how water resources of varying sizes respond to storm events and understand how costs may differ. Key catchment and lake characteristics for each lake, including land cover type, residence time, and wetlands, as well as depth, volume, and lake area have allowed us to identify important features that influence response to storm events. The surrounding populations are of varying size and economic status. We accounted for water sources that serve a large portion of Maine's population and also sources that might not have as many resources to implement adaptation strategies in order to identify how immediate action may differ and, in the future, allow us to understand long-term implications for different types of communities.

Objective 1: The selected 6 drinking water sources were sampled 24 hours before, 24-48 hours after and 5-7 days after an extreme precipitation event. Raw water was collected from the intake at each water utility to provide consistency, and this is the most relevant for water treatment and implications of extreme storm events on drinking water treatment.

Our measurements focused on DOC concentration and quality as well as phytoplankton community structure, as these are all the variables of primary concern for treatment as well as taste and odor problems. Using filtered water samples, DOC concentrations were analyzed on a Shimadzu TOC analyzer and DOC quality was assessed by measuring dissolved absorbance properties from 200-800 nanometers using a UV-VIS spectrophotometer. Whole water samples were preserved with Lugol's iodine solution for analysis of phytoplankton community. Phytoplankton for one storm event was identified to species on a Nikon TS-100 inverted microscope, with a minimum of 200 individuals counted per sample. Pre storm samples collected 24 hours before and post storm samples collected 5-7 days after the storm event were analyzed. We also measured nutrient and chlorophyll *a* concentrations to identify nutrient fluxes and changes in algal biomass that may occur as a result of storm events. Nutrients measured include total phosphorus, total nitrogen, nitrate, and ammonium.

To assess whether the storms altered DOC concentrations and DOC quality metrics between pre- and post-storm events within each of the 6 lakes individually, a one-way Analysis of Variance was used. A significance level of $p < 0.05$ was used and Levene's test for homogeneity and Shapiro-Wilks normality test were used to test for the assumptions of ANOVA. To determine which means were significantly different from one another, Tukey's honestly significant differences post-hoc test was used for each of the 6 lakes separately. To compare pre- and post-storm samples for phytoplankton in each lake, a one-way ANOVA with a Tukey's post-hoc test was used to assess differences between major taxa before and after the storm event as well as test for significant differences in major taxa within each the Pre and Post2 samples individually. A significance level of $p < 0.05$ was used.

Objective 2: The primary costs to measure are those aimed at maintaining communities' drinking water quality through the use of filtration or other technologies/approaches. Data collection to identify costs of improving or implementing filtration and/or treatment followed the Delphi Method; i.e., we will interactively survey water quality experts (e.g., water utility personnel, members of the Maine Water Utilities Association, water quality engineers, firms designing and selling water treatment and filtration systems, and others working on the issue of maintaining drinking water quality) to determine best estimates for appropriate systems to maintain water quality along with the costs of designing, implementing, maintaining, and operating the systems. These surveys allow us to understand the range of options available to maintain water quality and the respective costs.

Economic losses due to any decline in lake-water-quality will be calculated for each of the 6 lakes by combining information from a regression model (based on a recent meta-analysis of lake water quality studies) with lake and region characteristics. Variables in the model that influence estimated losses include: the starting water quality, the change in water quality, the region, and the size of the lake. Given that the problem (impacts from climate change) and the solution (building and financing infrastructures) have relatively long time horizons we will need to take into account both immediate and long-term losses, requiring the analysis to bring future losses into current dollar terms (i.e., calculate net present value of the stream of losses). As part of the sensitivity analysis we will vary the timeframes, discount rates, and possible population projections.

4. Principal Findings and Significance

A primary sustainability issue related to this research is how to identify, sustain, conserve, and protect Maine's high quality drinking water. This research addresses a relevant piece of this large issue by understanding the ecological and economic implications of climate driven changes on drinking water resources. The solution to this issue is complex in that both the ecological health of the ecosystem must be preserved and the economic impacts must be minimized, while allowing the economy to benefit from the water resources. The results of our research aim to address this solution.

Results evaluating the ecological response of the lakes suggest this research will provide data to assist water districts in future water quality management. The response of the lakes when comparing the different variables to one another (i.e. DOC versus nutrients or chlorophyll *a*) is variable. However when we evaluate the response of each lake to DOC three patterns of response emerge, an immediate spike in DOC concentrations followed by a return to pre-storm levels, a sustained increase in DOC over the sampling period, and no change in DOC. DOC quality metrics are influenced by seasonality and are more variable but, dependent on the DOC quality metric analyzed, illustrate consistent responses to that of DOC concentration. Key variables and drivers of these DOC changes include residence time, the ratio of watershed area to lake area, and lake size and depth. All nutrients evaluated in this study show little to no change over the course of the storm events and chlorophyll *a* responds inconsistently across lakes and storms. Phytoplankton increased in response to storm events, with the exception of the lake that has an immediate spike in DOC concentration and rapid flushing resulted in a decrease in

phytoplankton. This gives us insight into specific water quality changes that we will be able to translate into costs for drinking water utilities. Economic analyses are being conducted, therefore solutions have not yet been implemented however the relationships formed with stakeholders, primarily water district managers, will allow for collaborative development and implementation of adaptation and management strategies.

The researcher-stakeholder relationships have been fundamental to the success of this study. Water district managers of the 6 study lakes have been involved in all processes of the research and made it possible to collect a valuable dataset of information from which to evaluate the response of drinking water resources to extreme precipitation events and subsequent increases in DOC. Water district managers collected storm water samples and shipped them to the University of Maine for analysis. These managers have also provided information on their water treatment systems for economic analyses. This allowed for successful collection of samples from multiple lakes at the same time points, which would not have been possible otherwise.

This research has positioned us well for future funding and partnerships. The data and knowledge acquired from the study itself continue to build on our previous research about DOC and extreme precipitation events. With the information gained from this study we have tangible results that can be used to explain potential implications of climate on drinking water resources with water districts so that they can better understand and prepare for changes that may occur in the future. These same results and current partnerships will allow us to expand our partnerships within the state and from there consider other regions outside of Maine that will experience similar climate changes and work with these new partners to evaluate how their particular water source will respond to extreme storm events.

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Student support:

Kathryn Warner, Ph.D, Ecology and Environmental Sciences

Participation in this research for Kathryn is directly related to progression and completion of her dissertation, thus aiding in academic goals as well as career goals post graduation. The nature of this research is applied and engages several stakeholders in order to be successful. Kathryn learned to open channels of communication with stakeholders over the life cycle of the project, from developing the project idea to communicating results, thus in collaboration with Kathryn, the water utilities were able to assist in driving the research direction to find the best way to answer the most pressing research questions. This process was continuous for the duration of the project using an iterative and integrative approach for successful research. Participation in this research has allowed Kathryn to keep her career options open while pursuing applied research. Kathryn strengthened her communication skills with stakeholders and scientists enabling her and the water utilities to collect a large data set of information from water resources that were then analyzed and communicated back to the relevant stakeholders. Throughout this research, Kathryn engaged with several water district managers, which allowed them to modify what important metrics should be measured and would be most relevant and useful to the respective water districts. This improved her perspective on project development and ways to engage stakeholders in scientific research. Working with both an ecologist and economist allowed Kathryn to have multiple outlooks on ways to conduct research and understand various viewpoints when approaching a research problem. This was beneficial when engaging with stakeholders with different knowledge bases, and allowed Kathryn to better explain the research problem and relate ecological data to potential policy and management concerns.

Notable awards and achievements: N/A

Presentations:

- Warner, K.A. Assessing the implications of abrupt climate change on boreal and Arctic lakes. Climate Change Institute's Exploration and Discovery Rundown Event. February 8, 2018.
- Warner, K.A. Evaluating changes in epilimnion thickness and phytoplankton community structure from an extreme precipitation event, Global Lakes Ecological Observatory Network All Hands Meeting, New Paltz, NY, November 30, 2017
- Warner, K.A. Extreme precipitation and Maine's drinking water resources. Invited class lecture in Lake Ecology, University of Maine, Orono, Maine. November 9, 2017
- Warner, K.A. Investigating the response of Maine's drinking water lakes to extreme precipitation events. 11th Annual Maine Drinking Water Protection Seminar, Augusta, Maine. September 7, 2017
- Warner, K.A., Saros, J.E., and Teisl, M.F. Investigating the ecological response and economic vulnerability of Maine's drinking water resources to extreme precipitation events. Maine Sustainability and Water Conference, March 30, 2017, Augusta, Maine.
- Warner, K.A., Saros, J.E. Variable responses in lakewater dissolved organic carbon to extreme precipitation events. Association of Oceanography and Limnology Aquatic Sciences Meeting. March 3, 2017, Honolulu, Hawaii.
- Warner, K.A., Saros, J.E., Teisl, M.F. Investigating the response of Maine's drinking water resources to extreme precipitation events. 24th Annual Harold W. Borns, Jr. Symposium. April 14-15, 2016, University of Maine, Orono, Maine.
- Warner, K.A., Saros, J.E. Investigating the response of Maine's drinking water resources to extreme precipitation events. Maine Sustainability and Water Conference, March 29, 2016, Augusta, Maine.

Proposal Submissions: N/A**Publications:****Water Resources Research Institute Reports**

Saros, Jasmine; Kathryn Warner, Mario Teisl, 2017, Assessing the Vulnerability of Maine's Drinking Water Resources to Extreme Precipitation Events, Maine Water Resources Research Institute, University of Maine, Orono, Maine, 6pp.

REAL TIME DATA FOR SEBAGO LAKE TO SUPPORT SUSTAINABLE WATER RESOURCE MANAGEMENT, LAKE RESEARCH, UNDERGRADUATE RESEARCH TRAINING, AND COMMUNITY ENGAGEMENT

Basic Information

Title:	REAL TIME DATA FOR SEBAGO LAKE TO SUPPORT SUSTAINABLE WATER RESOURCE MANAGEMENT, LAKE RESEARCH, UNDERGRADUATE RESEARCH TRAINING, AND COMMUNITY ENGAGEMENT
Project Number:	2017ME322B
Start Date:	3/1/2017
End Date:	2/28/2018
Funding Source:	104B
Congressional District:	1
Research Category:	Water Quality
Focus Categories:	Water Quality, Education, Management and Planning
Descriptors:	None
Principal Investigators:	Emily Katherine Leshar, Brie Holme, Ryan Dorland, Nina Eduljee

Publication

1. Leshar, E., Holme, B., Dorland, R., Eduljee, N. Leveraging Real Time Data from a Water Quality Monitoring Buoy in Sebago Lake for Community Engagement: Preliminary Plans. Poster presentation at Maine Sustainability & Water Conference, Augusta, ME, March, 2017.

Update Report-5/1/18

Real Time Data for Sebago Lake to Support Sustainable Water Resource Management, Lake Research, Undergraduate Research Training, and Community Engagement

PI: Emily Leshar, Saint Joseph's College
Co-PIs: Brie Holme, Portland Water District
Ryan Dorland, Saint Joseph's College
Nina Eduljee, Saint Joseph's College

Summary

New England's lakes are changing in response to climate, use, and development stressors. Winter ice is forming later and melting earlier, giving algae an extended growing season. Increased rainfall and more frequent extreme storms mean more phosphorus and organic carbon-rich sediments wash into our lakes where they feed algae. Sebago Lake is the drinking water supply for 15% of Maine's population, and thus requires a proactive approach to sustaining its water quality in the face of multiple stressors.

The Portland Water District (PWD) has in the past conducted monthly sampling for traditional water quality parameters: temperature, dissolved oxygen (DO), Secchi disk clarity, Chlorophyll a , and total phosphorus. Monthly sampling provides only a snapshot of the lake throughout the monitoring season. Supported by this WRRRI project, we have purchased a Fondreist water quality monitoring buoy complete with a suite of sensors to monitor temperature, DO, water clarity via light attenuation, chlorophyll and pH. The buoy was purchased, received, constructed, tested, and deployed for a short "test run" between August and November 2017. The buoy successfully collected Sebago Lake water quality data between October 19 and November 21. Interestingly, even just this brief window of monitoring captured that lake turnover was coincident with the major "bomb cyclone" storm that hit New England on October 29-30 and caused widespread power outages. It will be deployed for the 2018 season in mid-May, depending on ice and weather conditions.

In addition to preparing the buoy for this year's monitoring season, we have outlined goals for engaging with the stakeholder groups identified in the proposal and begun outreach activities. We conducted a survey of sustainability perspectives and interest in the buoy data of ice fishermen during the Sebago Lake fishing derby. Data analysis is ongoing. We are also preparing for the summer research season and have hired student interns.

Problem and Research Objectives

There are a number of threats to the sustainability of Sebago Lake. In the face of complex challenges like development, climate change, and the lake's multiple uses, having good data is critical. With the purchase and deployment of the buoy, we have a much better picture of water quality parameters and moreover will have the complete record going into the future. We are currently preparing for making the real-time data publically available on the PWD website, GLEON and within a mobile app.

Continuing research objectives include:

- Engage with stakeholders to determine how best to interpret, visualize, and deliver lake data to increase their connection with and stewardship of Sebago Lake, particularly the recreational users.
- Create and assess educational modules that meet teachers needs and educate students on the challenges facing Sebago Lake, and the role of data and stakeholder investment in protecting the lake.
- Begin long term time series analysis of pH and inorganic carbon measurements.
- Compile lake data and data products for public consumption at the State of the Lake Symposium, currently scheduled for early 2019; develop and implement social methods for stakeholder engagement.

Methodology

Methods established in the first year of the project include:

- Necessary technical aspects of buoy deployment including calibration, communication, and installation.
- A survey instrument that was used to gain insights from ice fishing lake users.

Methodologies that are still being developed:

- Ways of interfacing with stakeholders at the State of the Lake Symposium, to effectively educate stakeholders on lake data and sustainable lake usage, while also learning from stakeholders and processing stakeholder knowledge into a structure to improve the overall state of knowledge on the lake.
- Methods to effectively develop modules for high school level science students.

Principal Findings and Significance

An essential problem for Sebago Lake has been a lack of high resolution data. Given the multiple stressors affecting the lake and its unique attributes (low productivity, depth), there has been little research into how Sebago has changed over time and how development, use and climate change might impact the water quality. A lack of high frequency data makes it difficult to pinpoint events or trends that impact a water quality parameter. Our fall test run of the buoy system very quickly yielded an interesting result. The October 29-30, 2017 storm that caused major power outages due to high winds (gusts greater than 80 mph in Southern Maine) initiated lake turnover. The physics of lake turnover, particularly in larger lakes, are not entirely understood and the buoy will now provide high quality data at a high level of temporal resolution. While we are still working on web interfaces and connecting global researchers to the data via GLEON, collecting water quality every 15 minutes during the ice-free season is a huge step forward.

At this point in the project we have only just begun to interact with stakeholders, notified them on the project and gleaned data from the ice fishing derby participants. This initial project will inform the next steps which will be commencing this summer. Key goals involving stakeholders are the design of the State of the Lake Symposium and the educational modules.

This project has already resulted in additional funding from two private foundations who wished to provide additional support for the State of the Lake Symposium and for student training. Additionally, we expect to pursue additional research funding related to physical lake modeling, and carbon/acidification measurements.

Student Support

Alyssa Charette, undergraduate, Biology and Secondary Education major at Saint Joseph's College. Alyssa has recently been hired onto the project as a research intern. She intends to become a high school science teacher and investigation into lake research is deepening her understanding of a crucial environmental topic. She will also be participating in developing lessons for high school science classes which is direct preparation for her career goal. She has also assisted with the survey results data analysis and has learned to use SPSS statistical software. In inputting the survey data, she was able to see the perspectives of a stakeholder group. The majority of her work will come this summer.

Notable awards and achievements: N/A

Presentations

Lesher, E., Holme, B., Dorland, R., Eduljee, N. Leveraging Real Time Data from a Water Quality Monitoring Buoy in Sebago Lake for Community Engagement: Preliminary Plans. Poster presentation at Maine Sustainability & Water Conference, Augusta, ME, March, 2017.

Holme, B., Lesher, E., Dorland, R., Eduljee, N. Real Time Data for Sebago Lake. Presentation at Lake Researchers' Retreat, Bridgton, ME, January 12, 2017.

Proposal Submission

Three proposals were prepared to private foundations to support additional student training and the State of the Lake Symposium, to be held in early 2019. \$7,250 has been awarded:

PI Dr. Emily Lesher
Second Abraham and Fannie Levey Foundation
September 1, 2017
\$1,500 requested. \$250 received

PI Dr. Emily Lesher
Margaret Burnham Charitable Trust
October 1, 2017
\$3,500 requested. \$3,500 received

PI Dr. Emily Lesher
Morton-Kelly Charitable Trust
October 1, 2017
\$3,500 requested. \$3,500 received

Publications: N/A

Improved delineation and analysis of Flood Attenuation in Maine's watersheds: Natural Infrastructure support of state of Maine's Clean Water Initiative (Chapter 589)

Basic Information

Title:	Improved delineation and analysis of Flood Attenuation in Maine's watersheds: Natural Infrastructure support of state of Maine's Clean Water Initiative (Chapter 589)
Project Number:	2017ME324B
Start Date:	3/1/2017
End Date:	2/28/2018
Funding Source:	104B
Congressional District:	2
Research Category:	Climate and Hydrologic Processes
Focus Categories:	Surface Water, Conservation, Floods
Descriptors:	None
Principal Investigators:	Shaleen Jain, David Courtemanch, Daniel R Coker

Publications

There are no publications.

WRI Project Annual Report

Improved delineation of natural infrastructure and capital as improved strategies for flood attenuation in support of State's "Clean Water for Maine" bond (P.L. 2013, Chapter 589)

The following is the list of PIs and affiliations:

PI: Jain, Shaleen, *Associate Professor, University of Maine*

Co-PI(s):

Courtemanch, David, *Freshwater Scientist, The Nature Conservancy, Maine*

Coker, Daniel R, *GIS Analyst, The Nature Conservancy, Maine*

Graduate Student: Prashanta Bajracharya, *Graduate Student, University of Maine, Maine*

1. Summary

The "General Fund Bond Issue to Ensure Clean Water and Safe Communities" and subsequent general funds affords increased investments towards natural and built infrastructure. This research seeks to develop methods to quantify the potential for natural infrastructure for hazard mitigation as well as understand the co-benefits they provide.

The primary goal of the project is to develop methods to quantify and effectively highlight the flood attenuation function that healthy floodplains can provide and effectively share that information with stakeholders and decision makers for conservation and restoration benefits. The 2m LiDAR-based DEM will be used to accurately map floodplain areas in two pilot areas in Maine, namely the lower Presumpscot watershed and the Mousam River watershed. These pilot projects have been chosen on the basis of data availability and system differences that could help determine the robustness of the modelling approach. The relative benefits of natural infrastructure for flood attenuation as well as other ecosystem services will be studied, modelled and quantified. Based on this, the natural infrastructure will be prioritized to provide support for decision making.

While the project is still in the preliminary stage, progress has been made in fleshing out the methodology for approaching this research undertaking. The need for place-based study and the value of involving local planners have been identified, and consequent steps have been taken. The team has an example case application of NI-GIS Methodology for floodplain delineation in the lower Presumpscot watershed.

2. Problem and Research Objective

With steady growth in urbanization and increasing climate variability, extreme hydrological events are becoming more common. Addressing this problem, while also promoting environmental sustainability, involves decreasing our reliance on built infrastructure, and shifting our focus towards natural infrastructure. This requires a meaningful framework for synthesizing available information regarding natural infrastructure assets. Furthermore, equally important is the study of valuation of benefits and policy tools for ecosystem service protection. Sustainability criteria involving systems analysis and information integration for decision support has yet to be realized.

Taking all this into account, the primary goal of the project is to develop methods to quantify and effectively highlight the flood attenuation function that healthy floodplains can provide, and effectively share that information with stakeholders and decision makers for conservation and restoration benefits. The specific objectives of the project are listed below:

- Development of a methodology, based on spatially explicit integration of geodata, community information, built infrastructure details, as well as floodplain information targeted at assessing the flood pulse attenuation and co-benefits to multiple sectors (including recreation).
- Analysis of historical flow records to understand the relationship between watershed characteristics and hydrologic regime to gain comprehension of the relative coherence and roles of various factors, such as forest cover, watershed storage, channel network characteristics, soil types, and floodplain extent and volume.
- Application of NI-GIS methodology to the lower Presumpscot watershed with retrospective analyses and semi-quantitative validation of the approach for past storms, using historical hydro-meteorological records and documentary information.

3. Methodology

Accurate mapping of floodplains

2m LiDAR-based DEM will be used to accurately map floodplains in two pilot areas in Maine. Coker is developing the model to overcome the issues with using the high-resolution DEM, and calibrating the floodplains using available data, including the 1996 southern Maine flood. Land cover and soil data will be incorporated to increase the accuracy of the floodplain maps and better model the hydrological response to extreme rainfall events.

Identification of wetland benefits

The relative flood attenuation benefits of the floodplain areas as natural infrastructure will be studied. The potential benefits of these areas to the downstream communities will be quantified and modelled. The vulnerable population and infrastructure will be identified and the benefits of upstream flood storage will be studied. The current conditions that may influence the effectiveness of the floodplain areas to perform flood attenuation function will be studied. The co-benefits of harnessing natural infrastructure will be identified.

Identification of key mapped floodplain areas

Key mapped floodplain areas that are priorities for protection and/or restoration in pilot watersheds will be identified. Through proper modelling approaches and scenarios analyses, the wetlands and floodplain areas will be prioritized to support decision making. Guidance on strategy implementation will be provided.

4. Principal Findings and Significance

The project is in the preliminary stages. Due to the late arrival of funding, Bajracharya could not be offered a Research Assistantship position and was offered a Teaching Assistantship Position for the first two semesters. During this time, he has been primarily involved in a literature review pertaining to the project. Meanwhile, Coker has been primarily involved in developing the NI-GIS methodology for stream and floodplain delineation, and testing it in the first pilot area, the lower Presumpscot watershed. The project team has received a no cost extension, with the plan to start Bajracharya on a Graduate Research Assistantship in June 2018.

The first team meeting was held in September 2017 between Jain, Courtemanch, and Bajracharya at the TNC office, Maine.

The second team meeting was conducted on January 10, 2018 between Jain, Courtemanch, Coker, and Bajracharya at the University of Maine. The primary objective of the meeting was to discuss the progress with the NI-GIS Methodology for floodplain delineation in the lower Presumpscot watershed. The challenges for the model, the data requirements, and the project plans going forward were discussed.

The third meeting was conducted on March 6, 2018 between Jain, Coker, and Bajracharya along with Robyn Saunders. Saunders is the Executive Director of the Cumberland County Soil and Water Conservation District. The primary objectives of the meeting were to identify a second pilot watershed to test the NI-Methodology and discuss to the potential involvement of Saunders in the project. After extensive discussion in the meeting and further discussion by email, Mousam River watershed was chosen as the second watershed. Having Saunders actively involved in this project helps in the place-based study of existing problems and practical solutions. Saunders will engage with potential stakeholders to understand the needs and priorities of stakeholders. Since it is the local managers that control local government, Saunders' involvement in the project facilitates communication with town managers. This leads to the understanding of governance and management constraints that can guide the project. By realizing the place-based needs and challenges, the hope is that the final outcome is a more implementable study report that fulfills the project objectives.

Bajracharya attended the 2018 Natural Capital Symposium from March 19 to March 22, 2018 at Stanford University. The symposium provided valuable information regarding the economics and valuation of ecosystem services, as well as trained him to use the InVEST model for mapping and valuing ecosystem services provided by land- and seascapes.

Student Support

One graduate student, Prashanta Bajracharya, will be supported on this project. Bajracharya is currently a master's degree student in Civil Engineering. The project has been an excellent learning opportunity for him. Bajracharya is interested in hydrological modelling and floodplain mapping, which is central to the project. Additionally, he aims to explore sustainable water management practices and low impact development. As such, this project is perfectly aligned with his research goals. Furthermore, the project has greatly increased his appreciation for the social, management, and policy aspects of water resources. Working in this project has allowed him to take a broader view of water resources management and stewardship.

Notable Awards and Achievements

None at this time.

Presentations

Coker, Daniel. "Creating Tools for Decision Makers." Influencing Conservation Policy, 2 April 2018, Senator George Mitchell Center for Sustainability Solutions, University of Maine, Orono, Maine.

Proposal Submissions

None at this time.

Publications

None at this time.

Contamination of Messalonskee Lake by pharmaceuticals and chemical ingredients in personal care products: an emerging ecological and public health threat

Basic Information

Title:	Contamination of Messalonskee Lake by pharmaceuticals and chemical ingredients in personal care products: an emerging ecological and public health threat
Project Number:	2017ME326B
Start Date:	3/1/2017
End Date:	2/28/2018
Funding Source:	104B
Congressional District:	1
Research Category:	Water Quality
Focus Categories:	Water Quality, Ecology, Toxic Substances
Descriptors:	None
Principal Investigators:	William G McDowell, Denise Ann Bruesewitz, Gail Carlson, Rachel Whitney

Publications

There are no publications.

USGS 104b (WRI) Investigator Annual Report
April 30, 2018

Project Title: Contamination of Messalonskee Lake by pharmaceuticals and chemical ingredients in personal care products: an emerging ecological and public health threat

Co-PIs:

- Gail Carlson, Assistant Professor, Environmental Studies Program, and Director of the Buck Environment and Climate Change Lab, Colby College
- Denise Bruesewitz, Assistant Professor, Environmental Studies Program, Colby College
- William McDowell, Assistant Professor, Biology Department, Merrimack College

Project Number: 2017ME326B

A. RESEARCH PROJECT

1. Summary:

Contamination of freshwater lakes and streams by pharmaceuticals and chemical ingredients from personal care product chemicals (PPCPs) is an emerging and alarming threat to ecosystems and public health. A growing body of research has documented PPCPs contamination of lakes and streams all over the world and the effects of these chemicals on aquatic ecosystems. Little is known about Maine's lakes, but in a previous study we detected the presence of caffeine, a caffeine metabolite, and amphetamine in several samples collected in early December on Great Pond, Long Pond and East Pond in the Belgrade Lakes chain.

Our current project expands on this previous study and was carried out primarily by a current Colby student, who is completely a senior honors thesis focused on this research. We sampled numerous sites of high and low human usage at four different times during the summer of 2017 on Messalonskee Lake, also located in the Belgrade Lakes chain. We analyzed our samples for total nitrogen and total phosphorus, and processed our samples for detection of 18 PPCPs, carried out by the Water Sciences Lab at the University of Nebraska. We also surveyed Messalonskee Lake watershed residents to gather information about drinking water and septic systems. We worked closely with the local watershed association *Friends of Messalonskee* to conduct this research.

We found detectable levels of five PPCP chemicals at numerous sample sites, with two high human use sites consistently having the most detections. PPCPs detected were caffeine, 1,7-dimethylxanthine (a caffeine metabolite), amphetamine, acetaminophen, and sulfachloropyridazine (a veterinary antibiotic). The largest number of PPCP detections were found during our first week of sampling (June 26, 2017), and detections decreased gradually over the subsequent six weeks of our sampling duration. Week of sampling, high human usage and total nitrogen were separately correlated with PPCP detection.

Survey results suggest that most residents get their drinking water from a drilled well, with only one respondent saying that they used lake water. Septic system age and time since last septic system inspection varied widely.

2. Problem and Research Objective:

Contamination of freshwater lakes and streams by pharmaceuticals and chemical ingredients from personal care product chemicals (PPCPs) is an emerging and alarming threat to ecosystems and public health. Numerous previous studies have documented the presence of a wide range of PPCPs in surface waters in the U.S. and around the world. Anthropogenic sources of these chemicals include wastewater treatment plants and various forms of run-off. Our research objective is to determine the extent of contamination of Messalonskee Lake by PPCPs and identify possible sources of these chemicals. This work builds on previous one-time sampling of other lakes in the Belgrade Lakes chain, which showed low levels of two PPCP chemicals with known human sources, caffeine and amphetamine.

3. Methodology:

Water samples were collected on Messalonskee Lake once every two weeks a total of four times over the summer season of 2017 (June 26 to August 7). Additional samples were collected on August 9 from Messalonskee Stream in Waterville and the Kennebec River upstream and downstream of Kennebec Sanitary Treatment Plant in Waterville. Thirteen sampling sites on the lake include a mix of privately and publicly owned properties, as well as three open water sites, and a mix of high and low human use sites.

Grab samples were collected in one-liter rinsed amber glass bottles at a water depth of approximately one meter, which ranged from 4.3 m to 11.2 m from shore. Open water samples were collected from the bow of a motorized boat, always facing upwind to avoid contamination from the boat. At each site on each sampling date, dissolved oxygen and temperature were measured using an Onset® HOBO® logger. General weather conditions were also recorded.

Samples were immediately stored on ice and were refrigerated within six hours. Onsite solid phase extraction (SPE) was performed to prepare the samples for liquid chromatography-mass spectrometry (LC-MS) no more than three days after collection. Using vacuum filtration, the samples were run through a 25 mm glass microfiber filter (1µm nominal pore size) into a 500-mg Oasis HLB cartridge (Waters, Milford, MA). Prior to running each sample, the system was conditioned with 5-10 mL of methanol followed by 5-10 mL of Milli-Q water. 100-500 mL of each sample were processed at an average flow rate of 9 mL/min. Afterwards, the cartridges were removed and frozen at -70 °C.

Samples were sent at room temperature to the Water Sciences Lab at the University of Nebraska for analysis of 19 PPCPs using liquid chromatography-tandem mass spectrometry followed by positive and negative ion detection.

We also collected duplicate samples at each site on two dates (July 24 and Aug 7) to analyze for total nitrogen and total phosphorus. These samples were collected in 60 mL acid-washed plastic bottles and stored frozen until analyzed using a LaChat QuikChem® analysis system.

Since the PPCP concentration data were non-normally distributed, a general linear model was employed (GLM) in R (v. 3.4.2) to compare factors such as site, site use, weather, nutrient levels, and sampling date. Depending on the data involved, the families “poisson” and “binomial” were used. GLMs were followed by a post-hoc general linear hypothesis test, which is used to determine groups that are significantly different when making multiple comparisons for parametric models.

An online survey was created asking Messalonskee Lake watershed residents to answer questions on their septic systems and drinking water sources (Qualtrics, Provo, UT). The survey was approved by the Colby Institutional Review Board for Research with Human Subjects before being released to the public (#2017-059). The survey was distributed to the public through word of mouth, the Friends of Messalonskee website and Facebook page, flyers posted in local businesses, and a hard copy provided at the town offices of each of the three towns surrounding Messalonskee Lake.

Maps of sampling sites and residential locations of survey respondents were generated using ArcGIS.

4. Principal Findings and Significance:

Analysis of our results is ongoing, so this summary represents a preliminary discussion of findings and significance. We detected PPCPs at most of the 13 sampling sites on Messalonskee Lake and at all three samples on Messalonskee Stream and the Kennebec River. Five chemicals were ever detected: caffeine, 1,7-dimethylxanthine, amphetamine, acetaminophen, and sulfachloropyridazine. More detections were found in our first week of testing and detections decreased as the weeks of the summer progressed; we found only one positive detection during the fourth week of sampling. Presence of PPCPs appears to be correlated with sampling week, with public sites that have high human usage, and with total nitrogen.

Results from the survey of lake residents showed that all but one respondent got their drinking water from a drilled well; one reported taking drinking water from the lake. Septic system age varied from < 10 to > 20 years. Time since last septic system inspection varied from < 1 to 32 years. A few respondents reported that they had heard of septic system leakage as a problem on Messalonskee Lake, but few reported any specific details.

These results are significant because they suggest that Messalonskee Lake is not highly contaminated with PPCPs but that certain chemicals are present and may suggest routes of anthropogenic contamination and possible causes for concern about human and wildlife exposures. There appears to be a significant temporal variable, which needs to be further explored. We have little indication that septic systems may be a source of lake contamination, including that private low human use sampling sites showed the least contamination, but more research is needed in this area.

This research addresses numerous problems in sustainability, including monitoring and maintaining water quality in a large watershed, addressing emerging issues in public health, notably PPCPs as surface water contaminants, surveying the health of septic systems in a

watershed, and considering possible ecological impacts of anthropogenic PPCPs in aquatic systems. Our research identifies PPCP contamination in the Belgrade Lakes chain in central Maine and begins to identify possible sources of these contaminants. Working with Friends of Messalonskee, the local watershed association, helped us do this research and will help us disseminate the results. Members allowed us access to their properties, drove us in their boat to access open-water sites, and publicized our survey, including at their annual meeting and on their website. Members have expressed great interest in our findings and a few will attend a research presentation this week by the Colby student involved in this project. Any changes to human usage and behaviors on or near the lake can only be done by residents themselves, so including Friends of Messalonskee as a research partner is critical.

This research project has revealed the extent of PPCP contamination in the Belgrade Lakes chain and suggests many follow-up experiments to determine further the spatial and temporal dynamics of PPCP contamination. Further research is also needed to identify anthropogenic sources of PPCPs in these lakes. Our significant findings position us well to seek funding to expand our project, and it may be valuable to study other lakes in partnerships with other lake associations.

B. OTHER REQUIRED DOCUMENTATION

Student support:

Alyssa Kullberg ('18), B.A. in Environmental Science (expected), Environmental Studies Program, Colby College

Alyssa has been working on all aspects of this project. She did all the water sampling and sample processing, designed the survey of lake residents, compiled all results, did statistical and spatial analyses, and generated all data figures and tables. She will complete a senior honors research thesis on this project in May 2018.

Alyssa is interested in pursuing graduate study in ecology, so this project has allowed her to gain valuable and relevant research skills, including in aquatic ecology, water sampling and analysis, statistical analyses, and use of human surveys. Alyssa has been interested in graduate study in ecology for a long time but doing this research has helped her see how interdisciplinary perspectives are valuable, particularly the importance of networking with and gathering information from stakeholders, in this case from lake residents. Alyssa noted that our research would not have been possible without the generous collaboration with one member of Friends of Messalonskee, who took us out on the lake in his boat each week of sampling, as well as members of this organization communicating with each other and reaching out to get respondents to our survey. Combining our aquatic sampling with a human survey has added to the story we are able to tell from this research, which Alyssa has realized as she has spent this semester analyzing all our data. Alyssa has reported to the PIs of this project how much she has learned from this research, and how much she has enjoyed it. Alyssa is an exceptionally promising young scholar who will go on to further study and will no doubt make significant contributions to the fields of ecology, environmental science and public health, and participating in this WRRI-funded research project has been an important part of her scholarly development.

Notable awards and achievements:

N/A

Presentations:

The student will present at the Colby Liberal Arts Symposium on Thursday, May 3, 2018, and will complete a senior honors research thesis in May. We plan to present our results to lake residents during the summer of 2018.

Proposal submissions:

To cover institutional matching funds, we submitted successful grant proposals to two internal Colby College grant sources.

- Colby's Goldfarb Center for Public Affairs faculty-student collaborative research grant; Lead PI: Gail Carlson; \$2,000 awarded March 2017.
- Colby's Interdisciplinary Studies Division faculty research grant; PI: Gail Carlson; \$3,000 awarded March 2017.

Publications:

During the summer of 2018, we will be summarizing this research in a manuscript for submission for publication.

(Seed Grant) Maine's Changing Winter: focus on natural resources, ecology, and the economy

(Seed Grant) Maine's Changing Winter: focus on natural resources, ecology, and the economy

Basic Information

Title:	(Seed Grant) Maine's Changing Winter: focus on natural resources, ecology, and the economy
Project Number:	2017ME327B
Start Date:	3/1/2017
End Date:	2/28/2018
Funding Source:	104B
Congressional District:	ME 02
Research Category:	Climate and Hydrologic Processes
Focus Categories:	Hydrology, Ecology, Economics
Descriptors:	None
Principal Investigators:	Sarah J Nelson, Karen Alice Wilson, Ivan Fernandez, Julia Daly, Jean D. MacRae, Glenn Hodgkins, Erik Blomberg, Mindy Crandall, Hamish Greig, Robert Dudley, Amanda Shearin

Publications

There are no publications.

Maine's changing winter: focus on natural resources, ecology, and the economy

2017 Interim Report

A. RESEARCH PROJECT

1. Summary

The character of Maine winters is changing. Warming temperatures and greater variability in precipitation hydrology — especially snowpack depth, density, and duration — have cascading effects on natural resources, wildlife ecology, and the economy. However, research regarding winter processes and impacts is only now beginning to emerge, and Maine does not yet have a coordinated effort to understand the state of the science or management implications of changing winter hydrology.

Winter air temperatures have increased, altering the persistence of snowpack and timing of snowmelt, important because snowpack often acts as a biological range limit. Furthermore, winter precipitation has increased but combined with warmer winter air, and Maine is likely to experience winters characterized by rain or sleet instead of snow, reducing snowpack and changing the magnitude or timing of hydrologic events. Across the Northeast, snowpack has already decreased by 4.6 cm and the length of snow-covered season has declined by 8.9 days per decade (Burakowski et al. 2008). In Maine, data indicate 15% reduction in snowfall since the late 1800s, and future projections suggest declines in snow accumulation in excess of 40% in coastal regions (Fernandez et al. 2015), and declines in maximum snowpack of ~75% with a 4°C temperature increase (Hodgkins & Dudley, 2013). Winter is a critical period for hydrology, wildlife, the biology of pests and pathogens, agriculture, human health, and economic activity. Winter conditions modulate spring melt processes, critical to the water quality, water quantity, and ecology of Maine's lakes and rivers. Snowmelt supplies recharge drinking water and hydro-power; thus, changing snow and ice cover will also affect the economics of human water use.

We lack a fundamental understanding of the role of winter dynamics, which limits our ability to identify effective resource management strategies. Further, changes in winter processes have economic implications for the forest (Rittenhouse & Rissman 2015) and recreational industries (e.g., \$3B/year for snowmobiling in the Northeast; Rustad et al. 2012). Winter is culturally important to recreation in Maine, supporting snowmobiling, skiing, snowshoeing, fishing, and tracking (Scott et al. 2008).

We conducted a two-day workshop to bring together researchers and professionals from academic and research institutions, government agencies, and non-profit organizations in Maine to establish a network of researchers interested in studying the ecosystem and societal impacts of Maine's changing winters. The principal outcome of this workshop was the development of collaborations to create a science-based foundation for future research proposals, stronger relationships between researchers and stakeholders and an improved awareness of stakeholder interests, and the identification and establishment of a common field site for monitoring and research and leverage efforts aimed at natural resource use and conservation. Efforts are still ongoing, and the researchers are working to establish new research and monitoring sites in Maine, as well as the development of an integrated winter ecology course that would be taught at multiple institutions within the University of Maine System.

Literature cited

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2. Problem and research objectives

The effects of winter dynamics on our natural resource based economy, and thereby the importance of winter's emerging rates of change, are poorly understood. Defining the nature and rates of change, anticipated future changes, and the implications for freshwater and terrestrial resources in Maine are critically important in achieving sustainability and economic vitality in the state.

Maine does not currently have a coordinated framework to maximize and strengthen expertise in winter ecology and the importance of changing winter hydrology on natural resources and Maine's economy. Thus, our goal was to formally develop a collaborative group of researchers and resource managers working throughout Maine to advance understanding of winter hydrology and ecology across Maine's seasonally snow-covered landscape. The primary function of this project was to coordinate efforts by:

- (1) convening a winter ecology workshop that would facilitate development of a research and management agenda to improve our understanding in this emerging field.
- (2) catalyzing establishment of shared observatory/research site(s) where fundamental questions about winter ecosystem processes can be explored.
- (3) developing a priority-based strategic research agenda ('perspectives document') that would inform decision-making with existing knowledge and focus research on critical information needs through a collaborative stakeholder process. A proposal arising from our shared research agenda will continue the partnership.

3. Methodology

The focus of this "seed" phase was to plan and convene a two-day workshop to synthesize existing scientific and experiential knowledge on the unique challenges and opportunities that are emerging for Maine's changing winter climate. The workshop, held in February 2018, was attended by researchers from the University of Maine, University of Southern Maine, and University of Maine – Farmington; teachers from local high schools like Old Town High School; federal and state agencies like US Geological Survey and Maine Department of Inland Fisheries

and Wildlife; as well as non-profit organizations like The Nature Conservancy and Manomet, Inc. The PIs and attendees met to develop a coordination network around winter ecology effects on wildlife and habitats. Each partner brought to the project critical expertise, data, regional interests, and understanding of scientific or management context.

Some attendees gave talks on how winter is changing, and what that means for our ecosystems and habitats. In breakout groups, we discussed the implications of winter climate change on (a) forest systems, (b) lake systems, (c) terrestrial wildlife and insects, and (d) from the human–social perspective. We discussed ways to integrate winter ecology research and education across different parts of the state and across the different UMS institutions.

4. Principal findings and significance

The discussions during the two-day workshop highlighted important aspects of winter climate change and possible research approaches — climate variability; phenology and phenological mismatch; and citizen science. The unifying research question was identified as: *How do changing ice and snow affect coupled natural and human (CNH) systems in Maine?*

We determined four broad goals:

1. Citizen science data collection: Establish sites near recreation areas (for easy access), where citizen scientists can help monitor variables such as presence/absence of snow, snowpack depth, lake ice depth, etc.
2. Cross-institutional course: Establish and conduct a course across several UMS (University of Maine System) campuses for the winter and/or spring semesters. Students would initially be taught the principles of winter ecology, and would then conduct research at sites close to their respective campuses. The course would culminate in a “Maine winter conference” (see point 3, below), where students across all campuses could come together (in-person or via distance technology) to present and discuss results from their projects. This would allow them to understand linkages among various ecosystem components and also understand both the similarities and differences among the climate divisions.
3. Convening a larger Maine-winter-snow conference: This would include students presenting their research from the cross-institution course, but also researchers and professionals in Maine studying various aspects of our changing winters.
4. Concepts paper: Use climate variability and phenological mismatches as a unifying concept, in the context of case studies (e.g. road salt, pests, lake ice and lake biology, etc.)

To address our goals, we are developing plans to establish research sites exhibiting a terrestrial–aquatic continuum (i.e. forest–stream–lake) that could be foci for research projects, be a part of citizen-science data collection campaigns, and/or be ‘winter observatories’ for academic courses and student research projects.

Significance

There is currently no statewide effort to coordinate knowledge, research priorities, and stakeholder concerns regarding changing winter conditions and its effects on water resources. The group of workshop attendees included researchers and professionals from University of Maine System campuses, Maine Department of Inland Fisheries and Wildlife (MDIFW), and the US Geological Survey (USGS), who are interested in developing an interdisciplinary focus on a changing winter and the impacts on Maine's freshwaters, wildlife, and natural resource based economy. Coordination among scientists and resource managers in this project is engaging other stakeholders interested in addressing priorities identified by this effort. Research arising from these collaborations will provide greater understanding of how Maine's changing winters will influence (a) freshwater systems; (b) forest systems; (c) wildlife; and (d) human activities including recreation; all of which have significant impacts on Maine's economy.

C. OTHER REQUIRED DOCUMENTATION

Student support:

One graduate student from the University Maine was hired to help coordinate the workshop and to write the subsequent reports. Kaizad Patel is a Ph.D. candidate in Ecology and Environmental Science in the School of Forest Resources at the University of Maine. His doctoral research focuses on winter soil function, and this workshop gave him the opportunity to interact with other researchers studying winter ecology in the state. This workshop helped him relate soil processes to other components of the ecosystem. Kaizad plans to conduct winter ecology research in his post-doctoral career.

Notable awards and achievements:

N/A

Presentations:

N/A

Proposal Submissions:

N/A

Publications:

N/A

Information Transfer Program Introduction

Information Transfer activities for the Maine Water Resources Research Institute (Maine WRRI) are an important part of our mission. Information Transfer activities can be categorized as: 1) Conferences and lectures; 2) Digital media; 3) K-12 education; 4) Stakeholder engagement; 5) Other project outputs; and 6) Student training.

In addition to the effort made directly by the Maine WRRI, we require funded researchers to include information transfer activities in their projects. This includes presentation of research results at the Maine Sustainability & Water Conference, creation of a project summary written for a general audience for web and print with assistance from our science writer, progress reports, and manuscripts for publication. All projects require that researchers engage with stakeholders with the goal of generating solutions-driven research.

Maine Information Transfer

Basic Information

Title:	Maine Information Transfer
Project Number:	2016ME317B
Start Date:	3/1/2016
End Date:	2/28/2018
Funding Source:	104B
Congressional District:	1
Research Category:	Not Applicable
Focus Categories:	Education, None, None
Descriptors:	None
Principal Investigators:	John M. Peckenham, David Hart

Publications

There are no publications.

1. Conferences and Lectures

Maine Sustainability & Water Conference

The Maine Sustainability & Water Conference was launched in 1994 with a primary focus on one of Maine's central challenges—the future of its water resources. Originally designed to provide a collaborative nexus for water resource professionals, researchers, consultants, citizens, students, regulators, and planners to exchange information and present new findings on water resource issues in Maine, the conference has grown to include participation from a broad audience of close to 400 participants from across the state. In response to many requests, the conference's focus has expanded to encompass a wide range of sustainability challenges facing Maine, including issues related to climate change, energy futures, agriculture, forestry, fisheries, tourism, and municipal planning. Many of these topics are also integrally interwoven with Maine's water resource issues and needs.

The conference continues to be the most important information transfer event for the Maine WRRI. In FY16 our plenary speaker was Carol Collier, Senior Advisor for Watershed Management and Policy at Drexel University Academy of Natural Sciences. Carol's talk was titled, *"Bridging the Gap between Science and Policy: Lessons Learned from the Delaware River Watershed"*. Carol shared her experiences from her 15+ years at the Delaware River Basin Commission and her current work on the Delaware River Watershed Initiative.

The conference included the following concurrent sessions:

- Climate Change and Extreme Events in Maine and the Northeast – Coastal Issues/Inland Issues
- Water Quality Monitoring: Innovations and Outcomes
- Stream Connectivity Resource Workshop
- Climate, Water + Health
- Safe Beaches & Shellfish
- Dams and Decision-making
- Research and Management of Maine's Drinking Water Sources and Watersheds
- A Rising Tide Floats All Boats – Innovative Strategies for Building Resilience through Collaboration
- Groundsource Heat Exchange – Geothermal Technologies for Heating and Cooling
- Channeling Cross-sector Collaboration for Healthy Maine Lakes
- Talking Trash: The Sustainability Challenge Hiding in Plain Sight
- Building a Sustainable Food System
- Land Conservation, Forestry, and the Future of Maine's Forest-dependent Economy
- Maine's Energy Future
- More Than an Island — Collaborative Water Research and Monitoring in Acadia National Park

A highlight of the conference is the student poster competition featuring undergraduate and graduate judging categories. Twelve undergraduate students and 17 graduate students presented posters at the 2016 conference. The undergraduate poster winner was Cailene

Gunn from Bates College with a poster titled, “Methane fluxes along a salinity gradient on a restored salt marsh, Harpswell, ME”. The graduate poster winner was Kelli Straka from the University of Maine’s School of Earth and Climate Sciences for her poster, “Quantifying groundwater exchange and variability of hydrologic fluxes in New England vernal pools.” Kelli’s research was funded by a FY15 WRII grant.

Full details about the conference, including links to presentations and award winners, can be found online at: umaine.edu/mitchellcenter/news/maine-water-conference/2016-maine-sustainability-water-conference/.

Senator George J. Mitchell Lecture on Sustainability

Launched in 2007, the Senator George J. Mitchell Lecture on Sustainability serves as an extraordinary forum in which the university community, the general public, and many others can learn from and interact with some of the world’s leading thinkers about the challenges and opportunities involved in accelerating the transition to a sustainable world. Sharing the stage with these extraordinary thought leaders, Senator Mitchell offers his compelling insights about the importance of sustainable development, a subject he first addressed in his 1991 book, *“World on Fire: Saving an Endangered Earth”*.

Ruth DeFries, Denning Family Professor of Sustainable Development at Columbia University, New York, gave the 2016 Mitchell Lecture. Ruth’s talk, “Between Optimism and Pessimism: Our Unending Pursuit to Feed Civilization”, was based on her book, *The Big Ratchet*, which traces the long journey of our species from hunters and gatherers to shoppers in the aisles of grocery stores. Through technologies, innovations, and quirks of fate, people over millennia have manipulated ecological processes to propel our species to the current day of abundant food amidst myriad environmental and social consequences. From this long-term view, the pattern shows neither collapse nor technological supremacy. Rather, our tenure on the planet reveals cycles of crisis and growth, with each innovation leading to a new set of ecological problems that in turn spur new innovations. Ruth discussed the next step in this long cycle toward science-based, non-ideological solutions to the problems that our success has created.

More information on this and prior Mitchell Lectures is available at: <https://umaine.edu/mitchellcenter/news/mitchell-lecture/>.

Weekly Speaker Series

The Mitchell Center hosts a weekly speaker series during fall and spring semesters. These talks are available via video conferencing and streaming for off-campus researchers, students and stakeholder, and are also recorded and posted to our Video-on-Demand page. In FY16 the following talks were supported in part by the Maine WRII:

- March 21, 2016 - Anticipating Surprises: The Role of Winter Weather-Climate Variability on Lake Ice Regimes in Maine. Speaker: Mussie Beyene, PhD Candidate, Civil & Environmental Engineering, UMaine

- March 28, 2016 - Bridging the Gap between Science and Policy: Lessons Learned from the Delaware River Watershed. Speaker: Carol Collier, Senior Advisor for Watershed Management and Policy, Drexel University Academy of Natural Sciences
- May 2, 2016 - A World Upside Down: Charting climate and biodiversity futures in Africa and the global south. Speaker: Phoebe Barnard, South African National Biodiversity Institute
- September 2, 2016 - Disturbance and Restoration in Streams. Speaker: Sam Lake, Emeritus Professor, Monash University, Melbourne, Australia⁶
- September 12, 2016 - Does the value of nature depend on whom you ask? Should it? Speaker: Aaron Strong, Assistant Professor, School of Marine Sciences, University of Maine
- September 26, 2016 - Indicators of Community Well-Being for Maine's Coast and Islands: Initial Results and Opportunities for Collaborative Research. Speaker: Heather Deese, Vice President, Research & Strategy, Island Institute
- October 3, 2016 - Conserving Small Natural Features with Large Ecological Importance. Speakers: Aram Calhoun and Malcolm 'Mac' Hunter, Professors, Wildlife, Fisheries & Conservation Biology, UMaine
- October 17, 2016 - Creating a Decision Support Toolbox for Safe Beaches & Shellfish Harvests. Speakers: Kate Beard, Damian Brady, Brian McGill, Bridie McGreavy, Sam Roy, Sean Smith; Decision Support Systems Team, NEST Safe Beaches & Shellfish
- November 7, 2016 - Resilient Communities and Fisheries Arise from Resilient Ecosystems. Speaker: Richard Merrick, Director, Scientific Programs and Chief Science Advisor, NOAA Fisheries
- November 14, 2016 - Scaling Conservation: Translating Local Success into Global Impact. Speaker: Kate Dempsey, State Director of The Nature Conservancy in Maine
- December 5, 2016 - Damned If You Do, Dammed If You Don't: The Evolution of Pro-Active Dam Removal over the Last Quarter Century. Speaker: Laura Wildman, Director, New England Regional Office, Princeton Hydro
- January 23, 2017 - From Frog Fungus to Smashed Dams; Maine science journalism and the (messed up) food chain of news. Speaker: Murray Carpenter, author and journalist
- February 20, 2017 - Food and Water Go Well Together – Pairing Stakeholder Engagement with Agriculture and Water Quality Management in the Chesapeake Bay Watershed. Speakers: Kelly Shenk, Agricultural Advisor, U.S. Environmental Protection Agency, Region III; Gary Shenk, Hydrologist, USGS at the Chesapeake Bay Program Office

2. Digital Media

Website

The Mitchell Center's web site is the most important location for finding information on upcoming events, current activities, projects and publications. Information on the Maine WRI is located on the Mitchell Center site and is updated on a regular basis. Information includes project summaries, outputs such as publications and presentations, and upcoming

funding opportunities such as proposal requests for 104b and 104g programs.

E-newsletter and News Posts

The Mitchell Center publishes an e-newsletter on a regular basis (every 2-3 weeks). Over 2,000 subscribers receive the newsletter, which includes short news articles and information on upcoming activities and events. The news articles in the e-newsletter link directly to full news posts on the Mitchell Center website. All information on Maine WRRI programs, such as requests for proposals, announcements of new projects, and related news articles and student stories, are included in the e-newsletter.

Facebook

The Mitchell Center's Facebook page is available at www.facebook.com/MitchellCenterForSustainabilitySolutions/. The page is used to provide brief updates and links to interesting information from the Mitchell Center and our researchers, students and partners. Our goal is to post 2-3 items per week. Interest in the page has increased significantly over the last 12 months and averages 400 likes per week.

3. K-12 Education

On Tuesday, October 11, 2016, the Maine WRRI helped organize and participate in the Northern Maine Children's Water Festival. Two Mitchell Center staff are directly involved in organizing the event. The festival, which is held every other year, promotes hands on learning about water issues and brings together over 650 fifth and sixth grade students and their teachers. Water resource professionals from Maine and New England provided presentations and activities about water, wetlands, human health and aquatic life; there were water trivia quiz shows hosted by local radio and television personalities, as well as activities using music and art. This experience was provided at no cost to the participants. In fact, the festival provided funding to help schools cover the cost of transportation. The festival goals are to teach students about the value of clean water and healthy habitats, and to provide teachers with materials and lessons that they can use for years to come.

We were very pleased with the level of participation and sponsorship for the 2016 festival, which was much higher than in prior years. Sponsors included private companies, academic institutions, non-governmental organizations, state government agencies and professional associations.

4. Stakeholder Engagement

The Mitchell Center's focus is on innovative stakeholder-engaged, solutions-driven, interdisciplinary research. As such, all research projects include active stakeholder involvement in as many aspects of projects as feasible. With an active network of partners across the state, the Mitchell Center can also assist investigators in connecting with appropriate stakeholders when needed.

The Maine WRRI Co-Directors serve on several state-wide and national boards and committees (e.g. Maine Water Utilities Association, New England Interstate Water Pollution

Control Commission, Penobscot River and Bay Institute, American Water Works Association, National Institutes for Water Research). These activities provide opportunities to promote relevant institute-sponsored research and education. It also provides a process for the Maine WRI to actively collect information about stakeholder concerns and challenges for water resources in the state and region.

Finally, the Maine WRI receives public inquiries on a regular basis. In general, inquiries are related to information on outcomes from funded projects or how new research may be focused on a topic of particular importance. Responding to these inquiries is a priority and we make every effort to help citizens find answers and solutions to their problems. Although most inquiries come from Maine, we have received requests from around the globe.

5. Other project outputs

Presentations

- 2016ME318B - Calhoun, A.J.K. Ecology and conservation of vernal pools. Annual meeting of the Lantrust Network, Topsham, Maine April 2017.
- 2016ME318B - Hoffmann, K. E. 2017. Ecology of Unisexual and Blue-Spotted Salamanders at Frog Pond. Presented to the Orono Land Trust Annual Meeting on March 31, 2017.
- 2016ME318B - Hoffmann, K. E. 2017. Vernal Pools for Me. A poster displayed in the lobby of the Maine Sustainability and Water Conference on March 30, 2017.
- 2016ME318B - Calhoun, A. J. K. 2017. Conserving Vulnerable Wetlands and Watersheds: a Portfolio Approach. Presented to the Maine Sustainability and Water Conference on March 30, 2017.
- 2016ME318B - Hoffmann, K. E. 2007. Vernal Pool Ecology. Presented to Downeast Audubon on March 23, 2017.
- 2016ME320B - Environmental Attitudes and Behaviors Course. (2016, May). Perceptions of metallic mineral mining in Maine. Class presentation at University of Maine's service learning class presentations, Orono, Maine.
- 2016ME320B - Morgan, A. (2016, September). Testimony of Andrew Morgan before the Board of Environmental Protection, Neither for nor against the proposed chapter 200: Metallic mineral exploration, advanced exploration and mining. Testimony presented at the Maine Board of Environmental Protection Public Hearing, Augusta, Maine.
- 2016ME320B - Morgan, A. (2016, December). Risk perceptions of metallic mineral mining in Maine. Thesis project proposal presented at the School of Forest Resources, Orono, Maine.
- 2016ME320B - Morgan, A. (2017, January). Public risk perceptions of metallic mineral mining in Maine: A mixed methods study. Abstract to present at the International Symposium on Society and Resource Management in Umeå, Sweden on June 19, 2017. Accepted.
- 2016ME319B - Warner, K.A., Saros, J.E. Variable responses in lakewater dissolved organic carbon to extreme precipitation events. Association for the Sciences of Limnology and Oceanography Annual Meeting. March 3, 2017, Honolulu, Hawaii.

- 2016ME319B - Warner, K.A., Saros, J.E., Teisl, M.F. Investigating the response of Maine's drinking water resources to extreme precipitation events. 24th Annual Harold W. Borns, Jr. Symposium. April 14-15, 2016, University of Maine, Orono, Maine
- 2016ME319B - Warner, K.A., Saros, J.E. Investigating the response of Maine's drinking water resources to extreme precipitation events. Maine Sustainability and Water Conference, March 29, 2016, Augusta, Maine

Proposal Submissions

- 2016ME320B - De Urioste-Stone, S. (Lead PI), Morgan, A. (Proposal Author). Travel to present grant proposal. University of Maine Graduate Student Government. February 9, 2017. Requested, \$850; awarded partial funding, \$425.
- 2016ME320B - De Urioste-Stone, S. (Lead PI), Morgan, A. (Proposal Author). 2017 Lee & Sunny Allen international experience travel scholarship. The School of Forest Resources, University of Maine. April 13, 2017. Requested, \$700; awarded full funding.
- 2016ME320B - Olsen, A. MacRae, J. & De Urioste-Stone, S.M. 2017. "Attitudes and impacts of mining in Maine: A comparative study". Requested \$36,314; proposal submitted to Water Resources Research Institute. (Unfunded).

Media Articles

- 2016ME320B - Shepherd, M. 2017. Why legislating mining in Maine is so hard, in one survey. News article from the Bangor Daily News. URL: <http://stateandcapitol.bangordailynews.com/2017/04/25/whylegislating-mining-in-maine-is-so-hard-in-one-survey/>
- 2016ME320B - Simms, D. (2017, March). Mitchell Center mining project data to be submitted for legislative consideration. Press release from the Senator George J. Mitchell Center for Sustainability Solutions. URL: <https://umaine.edu/mitchellcenter/category/news/>

Vernal pools for me

Basic Information

Title:	Vernal pools for me
Project Number:	2016ME318B
Start Date:	3/1/2016
End Date:	2/28/2018
Funding Source:	104B
Congressional District:	2
Research Category:	Not Applicable
Focus Categories:	Education, Wetlands, Ecology
Descriptors:	None
Principal Investigators:	Aram Calhoun

Publications

1. Hoffmann, Kristine. 2018. My First Field Guide to Vernal Pools. University of Maine, Orono, Maine, 55 pages.
2. Hoffmann, K. E. 2017. Vernal Pools for Me. Maine Sustainability and Water Conference, Augusta, ME. Poster presentation. March 30, 2017.

USGS 104b (WRI) Investigator Annual Report Information Transfer Project (Environmental Outreach)



Project title

Vernal Pools for Me

Investigators

Aram J. K. Calhoun, Professor of Wetland Ecology Department of Wildlife, Fisheries, and Conservation Biology, University of Maine, Orono, ME 04469-05775, (207) 581-3010, Calhoun@maine.edu

Kristine Hoffmann, Post-Doctoral Researcher, Department of Wildlife, Fisheries, and Conservation Biology, University of Maine

1. Summary

The *Vernal Pools for Me* project highlights and enhances the connection between citizens and their vernal pools by encouraging understanding of these special, small water resources through a portfolio of outreach materials. School children learn about the diversity of animals that use vernal pools and conservation through presentations, field walks, and a coloring book field guide. Lay people also benefit from easily accessible and engaging web-based outreach materials. This interdisciplinary outreach project built on knowledge and opportunities provided by (1) research conducted under the Sustainability Solutions Initiative and NSF-CNH Of Pools and People grant on community based conservation of pools, (2) the Special Area Management Plan (SAMP) for the New England Region of the Army Corps of Engineers created by the Vernal Pool Streamlining Working Group to put pool conservation in the hands of local people, and (3) a \$47,789 Environmental Protection Agency grant.

With the growth of social media, many conservation organizations now reach their audiences both on site and in homes. For example, organizations such as Hirundo Wildlife Sanctuary and Northeast Partners in Amphibian and Reptile Conservation are increasingly following their audience home through mobile and computer-based outreach. Similarly, we provide our partners with engaging material that they can use to educate their audiences through social media.

Products:

- Vernal pool coloring field guide for children
<http://www.vernalpools.me/vernal-pools-coloring-book/>
- Song for children “*Come to the pool*” performed by former UMaine Master’s student
Available online by August 2018
- Web comic describing the life cycle of vernal pool amphibians, illustrated by UMaine undergraduate student
<http://www.vernalpools.me/comic/>
- Presentations to schools and the public
Listed Below

2. Problem and Information Transfer Objectives

There were limited materials available for educators, children, and lay people wanting to learn about vernal pools. The Vernal Pool Association in Massachusetts has produced some printed materials and hosts vernal pool workshops for educators, and 4H recently created vernal pool kits for educators in Maine, but these materials are not readily available to the lay person and educators in other northeastern states. We created multi-media deliverables that can be used in the classroom, home, and/or field by anyone, anytime, anywhere to learn about these important ecosystems.

Our Objectives were to:

- Identify educational and outreach needs with our partners/citizens;
- Create a portfolio of outreach materials about vernal pools for a variety of ages and audiences to incorporate into the Of Pools and People web site;
- Host and solicit feedback on products from high school students; and
- Provide final deliverables online and in print

3. Methodology

Our web comic was developed by an undergraduate artist in 2017 and was released weekly online. Bangor High School's environmental science class provided feedback on the comic. We hired the student with additional funds to develop more comics and will be looking to publish them all in a vernal pool comic book. This and other web-based deliverables are posted on the University's vernalpools.me website (which hosts the NSF-CNH research and the Maine Vernal Pool and Mapping Assessment Program). Our consultant has expanded this website to include our materials.

Our Maine coloring book was printed and posted online in February 2018. We have received great feedback from educators and parents and have already distributed most of our 1,000 printed copies. By the end of the summer we will have versions of this book for other northeastern states on our website.

Our song-writer has recorded a draft version of the song and we have reviewed it. The final version of the song will be available on our website by the end of the summer.

4. Principal Findings and Significance

- **What problem in sustainability has your research addressed?**
For vernal pool amphibian communities in Maine and the Northeast to persist, people must be willing to conserve both the vernal pools and the surrounding terrestrial habitat. Several levels of regulation provide some regulation of activities around the subset of regulated vernal pools, but these laws alone are not enough to ensure amphibian persistence and vitality for future generations. Many pools are not covered by existing regulation or are unmapped and therefore unknown to their land owners and local governments. Furthermore, the regulations at the state level are constantly under threat from stakeholders wishing to eliminate regulatory restrictions. Clearly, an educated public will better appreciate the importance of these small water resources, understand

how the regulations work in their own interests, and may be less frustrated by the restrictions imposed at both state and federal levels of government. Our outreach work has provided memorable sources of information to influence the public's perspective on vernal pools and has encouraged educators to discuss these ecosystems with classes of children and the public.

- **To what extent has your research helped implement a solution to this problem?**

During this project we have presented information on vernal pools to 150 middle school children, 30 children, 20 high school students, and 100+ adults. Our comic has appeared on Facebook and the web page was accessed 258 times in 2017 and 192 times so far in 2018 (4/30/18). We have distributed about 800 printed copies of our coloring books to schools, NGO's, and the public, including the Isle au Haut Schoolhouse, Dedham School, Bangor High School, Bucksport Middle School, Hirundo Wildlife Society, Stillwater Montessori School, York County Audubon, Maine Environthon, the Children's Water Festival, Maine Sustainability and Water Conference, and others. This resource is available online and can be printed for free. The online coloring book has been accessed 116 times to date (4/30/18). Our song is nearing completion and both a music video and sheet music will be posted online by the end of the summer.

- **What roles have stakeholders played in your project's researcher-stakeholder partnership?**

We partnered with stakeholders to discuss products early in our planning stage. We received feedback on our ideas from Hirundo Wildlife Refuge, Stillwater Montessori School, and various parents of small children in the community. Protocols of our coloring books were reviewed by the above, and our comic strip was reviewed before posting by students at Bangor High School as well as by herpetologists and outreach specialists at Northeast Partners in Amphibian and Reptile Conservations. Our song was written, sung, and recorded by an alumna who is currently creating a music video of this product to post on You Tube. We have presented outreach events and distributed printed coloring books to schools, wildlife refuges, and the public.

- **How has this grant positioned you for future research funding and partnerships?**

This grant allowed us to demonstrate our ability to produce high quality outreach material. We will use this portfolio to show to future funders when we expand this work. We have found it easy to approach stakeholders and ask about what needs they have when they know that we will be proving them with digital and printed material.

C. OTHER REQUIRED DOCUMENTATION

Student support:

We hired one undergraduate, Laura Bollert, to create our web comic. Laura was a senior in the Department of Wildlife, Fisheries, and Conservation Biology.

- **How did participation in this research help the student reach his/her career goals?**

Laura intends to become a herpetologist and conservation biologist. This work

allowed her to remain active in the Calhoun Lab, attend lab meetings, and honed her presentation and communication skills.

- **Did participation in the research change the student's professional career goals?**
Laura was inspired by her new skills using a drawing tablet and Photoshop. While she still seeks to become a professional herpetologist, she now intends to use her artistic skills to help conservation in her future career. She purchased her own tablet after graduation so that she can continue to link science and art through illustrations.
- **What unique skills and experiences did the student gain from participation in the research?**
Laura learned how to use Photoshop to illustrate, how to use a drawing tablet, and learned about the differences between realistic drawings and why cartoons and comics need to be anthropomorphized. She learned to pick topics, outline a story, draw the characters, and write dialogue.
- **How did the student's engagement with stakeholders change his/her perspective?**
Laura worked with both scientists in the Calhoun lab and with high school students while developing and revising the comics. She struggled with the idea of anthropomorphizing the characters, and it was meeting with the graduate students and researchers in the lab that convinced her it was necessary to make the characters relatable.
- **How did the student's participation on an interdisciplinary research team change his/her perspective?**
NA

Notable awards and achievements:

This work has contributed to Kris Hoffmann's receiving two awards for her dedication to outreach as well as research:

- Edith Patch Award for Distinguished Graduate Work in Science, Agriculture, Engineering, or Environmental Education
- Outstanding Graduate Student in the Department of Wildlife, Fisheries, and Conservation Biology for 2017.

Presentations:

Hoffmann, K. E. 2017. Ecology of Unisexual and Blue-Spotted Salamanders at Frog Pond. Presented to the Orono Land Trust Annual Meeting on March 31, 2017.

Hoffmann, K. E. 2017. Vernal Pools for Me. A poster displayed in the lobby of the Maine Sustainability and Water Conference on March 30, 2017.

Calhoun, A. J. K. 2017. Conserving Vulnerable Wetlands and Watersheds: a Portfolio Approach. Presented to the Maine Sustainability and Water Conference on March 30, 2017.

Hoffmann, K. E. 2017. Vernal Pool Ecology. Presented to Downeast Audubon on March 23, 2017.

Hoffmann, Kristine. 2017. Frogs of Maine. Presented to York Audubon, 19 September, Wells, Maine

Hoffmann, Kristine. 2018. Amphibian Research. Presentation to the Maine Conservation Corps. 17 January, Augusta, Maine

Hoffmann, K., T. Hastings, M. Jones, A. Calhoun, and M. Hunter. 2018. Wood Frog Movement and Habitat Selection in Urban Settings. Presented at the Northeast Natural History Conference. April 13. Burlington, Vermont.

Hoffmann, Kristine. 2018. Vernal Pool Research and Ecology. Public presentation at the Vernal Pool 101 workshop by the Maine Lake Science Center, 24 March, Bridgeton, Maine

Hoffmann, Kristine. 2018. Frog Calling Workshop. Public workshop presented with Hirundo Wildlife Refuge, 25 March, Orono, Maine

Hoffmann, Kristine. 2018. Frogs of Maine. Presented to York Audubon, 17 April, Wells, Maine

Hoffmann, Kristine. 2018. Vernal Pools for Me. Field trip with the Stillwater Montessori School, 26 April, Orono, Maine

Hoffmann, Kristine. 2018. Vernal Pool Management. Field Trip with WLE 431, 25 April, Old Town, Maine

Hoffmann, Kristine. 2018. Vernal Pools for Me. Public field trip with Hirundo Wildlife Refuge, 28 Aprils, Alton, Maine

Hoffmann, Kristine. 2018. Frog Calling Walk. Public field trip at Hirundo Wildlife Refuge, 19 May, 2018

Proposal Submissions:

2016 – Calhoun, Foundation for Salamander Conservation, requested \$5000, received \$500

2015 – Calhoun, Maine Outdoor Heritage Fund, requested \$19,534, none received

Publications:

Hoffmann, Kristine. 2018. My First Field Guide to Vernal Pools. University of Maine, Orono, Maine, 55 pages.

Maine Information Transfer

Basic Information

Title:	Maine Information Transfer
Project Number:	2017ME328B
Start Date:	3/1/2017
End Date:	2/28/2018
Funding Source:	104B
Congressional District:	2
Research Category:	Not Applicable
Focus Categories:	Education, None, None
Descriptors:	None
Principal Investigators:	David D. Hart, John M. Peckenham

Publications

There are no publications.

WRI Project Annual Report FY17 Information Transfer

1. Conferences and Lectures

Maine Sustainability & Water Conference

The Maine Sustainability & Water Conference was launched in 1994 with a primary focus on one of Maine's central challenges—the future of its water resources. The conference was originally designed to provide a collaborative nexus for water resource professionals, researchers, consultants, citizens, students, regulators, and planners to exchange information and present new findings on water resource issues in Maine. It has now grown to include participation from a broad audience of close to 400 participants from across the state. In response to many requests, the conference's focus has expanded to encompass a wide range of sustainability challenges facing Maine, including issues related to climate change, energy futures, agriculture, forestry, fisheries, tourism, and municipal planning. Many of these topics are also integrally interwoven with Maine's water resource issues and needs.

The conference continues to be the most important information transfer event for the Maine WRI. The 2017 conference took place on Thursday, March 30 at the Augusta Civic Center, Augusta, ME. The keynote speaker was Aram Calhoun, a professor in the Dept. of Wildlife Ecology, Fisheries and Conservation at the University of Maine. Calhoun's talk was titled, "Conserving Vulnerable Wetlands and Watersheds: A portfolio approach". Calhoun has been a PI/Co-PI on several Maine WRI funded projects.

The conference included the following water-related concurrent sessions:

- Understanding Lake Tipping Points
- Circa 1971: Efficacy of Shoreland Zoning in Protecting Water Resources
- Repairing Maine's "Open Sewers": Historical Reflections
- To Green or Not to Green? Meeting your municipal infrastructure needs
- Rain and Tides – How communities are addressing evaluation, engagement, planning, and mitigation in an age of unpredictable water
- Understanding and Managing Land-Sea Connections Along the Maine Coast
- Cyanotoxin – Phytoplankton's Revenge or The Empire Strikes Back
- Contaminants in Maine Waters
- New Approaches to Integrating Wetland Conservation into Land-use Planning
- Climate Action under Current Conditions: What's Happening in Maine?

A highlight of the conference is the student poster competition featuring high school, undergraduate and graduate judging categories. The 2017 conference featured six high school posters, 19 undergraduate posters, and 17 graduate posters.

Full details about the conference, including links to presentations and poster award winners, can be found online at umaine.edu/mitchellcenter/2017-conference/

Senator George J. Mitchell Lecture on Sustainability

Launched in 2007, the Senator George J. Mitchell Lecture on Sustainability serves as an extraordinary forum in which the university community, the general public, and many others can

learn from and interact with some of the world's leading thinkers about the challenges and opportunities involved in accelerating the transition to a sustainable world. Sharing the stage with these extraordinary thought leaders, Senator Mitchell offers his compelling insights about the importance of sustainable development, a subject he first addressed in his 1991 book, *"World on Fire: Saving an Endangered Earth"*.

The 2017 Mitchell Lecture on Sustainability took place on Thursday, September 21 at the University of Maine, and was attended by over 450 people. The keynote speaker was Thomas Dietz. Dietz is a professor of Sociology and Environmental Science and Policy at Michigan State University. At MSU he was founding director of the Environmental Science and Policy Program and associate dean in the colleges of Social Science, Agriculture and Natural Resources and Natural Science, and assistant vice president for environmental research.

Dietz's talk was titled, "Facts versus Values: How can we make better decisions?" Dr. Dietz provided the following overview of his talk: "The 21st century will see unprecedented transformations in human life and vast changes on planet Earth. Challenges such as the problems of sustainability and emerging technologies will require difficult decisions based on both science and our values. There seems to be a broad consensus that we should improve human well-being while protecting the environment, but research shows that there are many obstacles to good decision making by individuals, organizations and government. How can we do better? While the obstacles we face are formidable, research on decision making provides ideas on how we can move forward to make decisions that better reflect both the facts and our values."

More information on this and prior Mitchell Lectures is available at:
umaine.edu/mitchellcenter/news/mitchell-lecture/.

Weekly Speaker Series

The Mitchell Center hosts a weekly speaker series during fall and spring semesters. These talks are available via video conferencing and streaming for off-campus researchers, students and stakeholders, and are also recorded and posted to our Video-on-Demand page (vimeo.com/mitchellcenterumaine). In FY17, the following talks were supported in part by the Maine WRRI:

March 20, 2017

Frankenfood or Farm Fresh? Communicating Aquaculture's Promises and Perils
Laura Rickard, Assistant Professor, Communication & Journalism, UMaine

April 3, 2017

Dams and Fish: Understanding our impounded legacy
Joseph Zydlewski, Professor, Wildlife, Fisheries, & Conservation Biology; Assistant Unit Leader, USGS Maine Cooperative Fish and Wildlife Research Unit

April 10, 2017

From magnifying glass to microscope: the new National Water Model
David Maidement, Hussein M. Alharthy Centennial Chair in Civil Engineering, University of Texas at Austin

April 17, 2017

Taking an integrative view of the Mexico City sustainability challenge

Timothy Downs, Associate Professor, Environmental Science and Policy, Clark University

May 1, 2017

The Long Road from Pollution to Protection: History in the Making

Matt Scott, Aquatic Biologist

September 11, 2017

Damming Decisions: Searching for sustainable solutions in New England rivers

Sam Roy, Postdoctoral Researcher, Mitchell Center for Sustainability Solutions

September 18, 2017

Protecting Maine's Greatest Resource

Melanie Loyzim, Deputy Commissioner, Maine Department of Environmental Protection

September 29, 2017

Sustainability Success through Community Conservation

Anthony Charles, School of the Environment and School of Business, Saint Mary's University, Halifax, Nova Scotia

October 2, 2017

Putting human population growth and attendant consumption back on the radar screen: A fisheries perspective

Karin Limburg, Professor, State University of New York College of Environmental Science and Forestry

October 16, 2017

The Politics of a Sustainable Coast: Money, Science, Democracy, and Climate in Southeastern Louisiana

Michael Haedicke, Associate Professor of Sociology, Drake University

October 23, 2017

Build it and they will come

Tony Grassi, sustainability entrepreneur

November 6, 2017

A Conversation About Decision Support Tools: What are they? When are they useful? What problems might they solve?

Interdisciplinary panel discussion

November 13, 2017

Sustainability Lightning talks

Eight students present five-minute talks on their sustainability research in Maine.

2. Digital Media

Website

The Mitchell Center's web site is the most important location for finding information on upcoming events, current activities, projects and publications. Information on the Maine WRRI is located on the Mitchell Center site and is updated on a regular basis. Information includes project summaries, outputs such as publications and presentations, and upcoming funding opportunities such as proposal requests for 104b and 104g programs (umaine.edu/mitchellcenter/).

E-newsletter and News Posts

The Mitchell Center publishes an e-newsletter on a regular basis (3-4 weeks). Over 2,000 subscribers receive the newsletter, which includes short news articles and information on upcoming activities and events. The news articles in the e-newsletter link directly to full news posts on the Mitchell Center website. All information on Maine WRRI programs, such as requests for proposals, announcements of new projects, and related news articles and student stories, are included in the e-newsletter.

Facebook

The Mitchell Center's Facebook page is available at facebook.com/MitchellCenterForSustainabilitySolutions/. The page is used to provide brief updates and links to interesting information from the Mitchell Center and our researchers, students and partners. Our goal is to post 2-3 items per week. Interest in the page has increased significantly over the last 12 month. The Facebook page reaches an average of 100 people each week and can reach over 500 people depending on specific posts. All WRRI-related information is posted to our Facebook page with links to more detailed website information.

3. K-12 Education

Maine WRRI helps organize and participate in the Northern Maine Children's Water Festival. Two Mitchell Center staff are directly involved in organizing the event and many more students, staff and faculty participate the day of the festival. Although 2017 was an off year for the festival (it takes place every other year), planning for the 2018 event is underway. Mitchell Center staff have participated in planning meetings of the Festival Committee which includes representatives from state government, non-profit organizations, the private sector and UMaine Cooperative Extension.

4. Stakeholder Engagement

The Mitchell Center's focus is on innovative stakeholder-engaged, solutions-driven, interdisciplinary research. As such, all research projects, including Maine WRRI projects, involve active stakeholder involvement in as many aspects of projects as feasible. With an active network of more than 400 stakeholder partner organizations across the state, the Mitchell Center regularly assists researchers in connecting with appropriate stakeholders when needed.

The Maine WRRI receives public inquiries on a regular basis. In general, inquiries are related to information on outcomes from funded projects or how new research may be focused on a topic of particular importance. Responding to these inquiries is a priority and we make every effort to help citizens find answers and solutions to their problems. Although most inquiries come from Maine, we have received requests from around the globe.

5. Other project outputs

Presentations

- 2016ME318B - Calhoun, AJK. Ecology and conservation of vernal pools. Annual meeting of the Lantrust Network, Topsham, Maine. April 2017.
- 2016ME318B - Hoffmann, K. E. 2017. Ecology of Unisexual and Blue-Spotted Salamanders at Frog Pond. Presented to the Orono Land Trust Annual Meeting on March 31, 2017.
- 2016ME318B - Hoffmann, K. E. 2017. Vernal Pools for Me. A poster displayed in the lobby of the Maine Sustainability and Water Conference on March 30, 2017.
- 2016ME318B - Calhoun, A. J. K. 2017. Conserving Vulnerable Wetlands and Watersheds: a Portfolio Approach. Presented to the Maine Sustainability and Water Conference on March 30, 2017.
- 2016ME318B - Hoffmann, K. E. 2017. Vernal Pool Ecology. Presented to Downeast Audubon on March 23, 2017.
- 2016ME318B - Hoffmann, Kristine. 2017. Frogs of Maine. Presented to York Audubon, 19 September, Wells, Maine
- 2016ME318B - Hoffmann, Kristine. 2018. Amphibian Research. Presentation to the Maine Conservation Corps. 17 January, Augusta, Maine
- 2017ME322B - Holme, B., Leshner, E., Dorland, R., Eduljee, N. Real Time Data for Sebago Lake. Presentation at Lake Researchers' Retreat, Bridgton, ME, January 12, 2017.
- 2016ME319B - Warner, K.A. Assessing the implications of abrupt climate change on boreal and Arctic lakes. Climate Change Institute's Exploration and Discovery Rundown Event. February 8, 2018.
- 2016ME319B - Warner, K.A. Evaluating changes in epilimnion thickness and phytoplankton community structure from an extreme precipitation event, Global Lakes Ecological Observatory Network All Hands Meeting, New Paltz, NY, November 30, 2017
- 2016ME319B - Warner, K.A. Extreme precipitation and Maine's drinking water resources. Invited class lecture in Lake Ecology, University of Maine, Orono, Maine. November 9, 2017
- 2016ME319B - Warner, K.A. Investigating the response of Maine's drinking water lakes to extreme precipitation events. 11th Annual Maine Drinking Water Protection Seminar, Augusta, Maine. September 7, 2017
- 2016ME319B - Warner, K.A., Saros, J.E. Variable responses in lakewater dissolved organic carbon to extreme precipitation events. Association of Oceanography and Limnology Aquatic Sciences Meeting. March 3, 2017, Honolulu, Hawaii.
- 2015ME309B - Yaparathne, S., C.P. Tripp, and A. Amirbahman, "The development of powder modified immobilized catalyst films to enhance UV assisted degradation of taste and odor causing compounds in drinking water." New England Graduate Student Water Symposium, Amherst, MA, September 2017.

Proposal Submissions

- 2016ME318B – 2016. Calhoun, A. Foundation for Salamander Conservation. Requested \$5000. Awarded partial funding. \$500
- 2016ME318B – 2015. Calhoun, A. Maine Outdoor Heritage Fund. Requested \$19,534. Not funded.
- 2017ME326B – 2017. Carlson, Gail. Colby's Goldfarb Center for Public Affairs Faculty-Student Collaborative Research Grant. Awarded \$2,000.
- 2017ME326B – 2017. Carlson, Gail. Colby's Interdisciplinary Studies Division Faculty Research Grant. Awarded \$3,000.
- 2017ME322B – 2017. Leshner, Emily. Second Abraham and Fannie Levey Foundation. \$1,500 requested. \$250 awarded.
- 2017ME322B – 2017. Leshner, Emily. Margaret Burnham Charitable Trust. \$3,500 requested. \$3,500 awarded.
- 2017ME322B – 2017. Leshner, Emily. Morton-Kelly Charitable Trust. \$3,500 requested. \$3,500 awarded.

Media Articles

- 2016ME318B – Kaplan, Sarah. July 2017. In nature, the littlest things can have the biggest impact. Speaking of Science article from The Washington Post. URL: <https://tinyurl.com/yagjtevc>

6. Student Training

2016ME319B

Kathryn Warner, Ph.D. candidate, Ecology and Environmental Sciences, UMaine

Participation in this research for Warner is directly related to progression and completion of her dissertation, thus aiding in academic goals as well as career goals post-graduation. The nature of this research is applied and engages several stakeholders in order to be successful. Warner learned to open channels of communication with stakeholders over the life cycle of the project, from developing the project idea to communicating results. Thus, in collaboration with Warner, the water utilities were able to assist in driving the research direction to find the best way to answer the most pressing research questions. This process was continuous for the duration of the project using an iterative and integrative approach for successful research. Participation in this research has allowed her to keep her career options open while pursuing applied research. Warner strengthened her communication skills with stakeholders and scientists enabling her and the water utilities to collect a large data set of information from water resources that were then analyzed and communicated back to the relevant stakeholders. Throughout this research, she engaged with several water district managers, which allowed them to modify what important metrics should be measured and would be most relevant and useful to the respective water districts. This improved her perspective on project development and ways to engage stakeholders in scientific research. Working with both an ecologist and economist allowed Warner to have multiple outlooks on ways to conduct research and understand various viewpoints when approaching a research problem. This was beneficial when engaging with stakeholders with different knowledge bases, and allowed her to better explain the research problem and relate ecological data to potential policy and management concerns.

2016ME318B

Laura Bollert, undergraduate, Dept. of Wildlife Fisheries & Conservation Biology, UMaine

Bollert was hired to help develop a web comic for this project. She plans on becoming a herpetologist and conservation biologist and this work allowed her to remain active in the Calhoun Lab, attend lab meetings, and honed her presentation and communication skills. Bollert learned new skills including using Adobe Photoshop for illustrations, using a drawing tablet, and learning about the differences between realistic drawings and why cartoons and comics need to be anthropomorphized. She learned to pick topics, outline a story, draw the characters, and write dialogue. While she still seeks to become a professional herpetologist, she now intends to use her artistic skills to help with conservation goals in her future career. She plans to continue to link science and art through illustration. While developing and revising the comics, Bollert worked with both scientists and high school students to help make the characters relatable. The comic can be found at vernalpools.me/comic/.

2017ME324B

Prashanta Bajracharya, MS student, Civil & Environmental Engineering, UMaine

This project has provided an excellent learning opportunity for Bajracharya. He is interested in hydrological modelling and floodplain mapping, which is central to the project. Additionally, he aims to explore sustainable water management practices and low impact development. As such, this project is perfectly aligned with his research goals. Furthermore, the project has greatly increased his appreciation for the social, management, and policy aspects of water resources. Working in this project has allowed him to take a broader view of water resources management and stewardship.

2017ME322B

Alyssa Charette, undergraduate, Biology and Secondary Education, Saint Joseph's College

Charette was recently hired onto the project as a research intern. She intends to become a high school science teacher and investigation into lake research is deepening her understanding of a crucial environmental topic. She will also be participating in developing lessons for high school science classes which is direct preparation for her career goal. She has assisted with survey result data analysis and has learned to use SPSS statistical software. In inputting the survey data, Charette was able to see the perspectives of a stakeholder group. The majority of her research will take place this summer.

2017ME326B

Alyssa Kullberg, undergraduate, Environmental Studies Program, Colby College

Kullberg has worked on all aspects of this project. She conducted all the water sampling and sample processing, designed the survey of lake residents, compiled results, did statistical and spatial analyses, and generated data figures and tables. She will complete a senior honors research thesis on this project in May 2018. Kullberg is interested in pursuing graduate study in ecology, so this project has allowed her to gain valuable and relevant research skills, including in aquatic ecology, water sampling and analysis, statistical analyses, and use of human surveys. Kullberg has been interested in graduate study in ecology for a while but this research has helped her see how interdisciplinary perspectives are valuable, particularly the importance of networking with and gathering information from stakeholders, in this case from lake residents. Combining our aquatic sampling with a survey has added to the story we are able to tell from this

research, which Kullberg realized as she spent time analyzing the data. Kullberg is an exceptionally promising young scholar who will go on to further study and will no doubt make significant contributions to the fields of ecology, environmental science and public health. Her participation in this WRRI-funded research project has been an important part of her scholarly development.

2017ME327B

Kaizad Patel, Ph.D. candidate, Ecology and Environmental Science, University of Maine

Patel was hired to help coordinate the project workshop and to write subsequent reports. His doctoral research focuses on winter soil function, and this workshop gave him the opportunity to interact with other researchers studying winter ecology in the state. This workshop helped him relate soil processes to other components of the ecosystem. Patel plans to conduct winter ecology research in his post-doctoral career.

USGS Summer Intern Program

None.

Student Support					
Category	Section 104 Base Grant	Section 104 NCGP Award	NIWR-USGS Internship	Supplemental Awards	Total
Undergraduate	3	0	0	0	3
Masters	1	0	0	0	1
Ph.D.	2	0	0	0	2
Post-Doc.	1	0	0	0	1
Total	7	0	0	0	7

Notable Awards and Achievements

Doctoral student Kristine Hoffman received the Edith Patch Award for Distinguished Graduate Work in Science, Agriculture, Engineering, or Environmental Education in 2017.

Doctoral student Kristine Hoffman received the award for Outstanding Graduate Student from the Department of Wildlife, Fisheries, and Conservation Biology at the University of Maine in 2017.

Masters student Andrew Morgan was awarded a 2017 Lee & Sunny Allen International Experience Travel Scholarship to present his thesis work.

Masters student Andrew Morgan received a Graduate Student Government (GSG) award to attend and present at the 23rd ISSRM conference in Umeå, Sweden, June 2017.

Publications from Prior Years

1. 2014ME297B ("Controls of phosphorus cycling in Lake Auburn, Maine, USA: Spatial and temporal interactions among sediment, water column, and climate change") - Articles in Refereed Scientific Journals - Doolittle H.A., S.A. Norton, L.C. Bacon, H.A. Ewing, and A. Amirbahman, "The internal and watershed controls on hypolimnetic sediment phosphorus release in Lake Auburn, Maine, USA." Lake and Reservoir Management. <https://doi.org/10.1080/10402381.2018.1423588>.
2. 2015ME309B ("Toward a more efficient UV disinfection system: The development of a TiO₂-based photocatalyst to enhance the degradation of taste and odor compounds in drinking water") - Articles in Refereed Scientific Journals - Yaparathne S., C.P. Tripp, and A. Amirbahman, "Photodegradation of taste and odor compounds in water in the presence of immobilized TiO₂-SiO₂ photocatalysts." Journal of Hazardous Materials, 2018, 346, 208-217.
3. 2013ME293B ("Optimized Pre-Treatment for Fluorescence Monitoring of Surface Fresh Water Contamination") - Articles in Refereed Scientific Journals - Pan Z., E.A. Stemmler, W. Fan, L.A. Leblanc, H.H. Patterson, and A. Amirbahman, "Photocatalytic degradation of 17 β -ethinylestradiol (EE2) in the presence of TiO₂-doped zeolite." Journal of Hazardous Materials, 2014, 279, 17-25.
4. 2015ME313B ("Water budget, groundwater exchange and hydrologic variability of central Maine") - Dissertations - Kelli M. Straka,. 2017. Characterizing Hydrologic Fluxes in Six Central Maine Vernal Pools with a Focus on Groundwater Flow. M.S. Thesis. University of Maine.
5. 2016ME320B ("Mining in Maine: Exploring Public Perceptions") - Other Publications - Morgan, A., De Urioste-Stone, S.M., MacRae, J. & Noblet, C. (2017). Public risk perceptions of metallic mineral mining in Maine: A mixed-method study. 23rd ISSRM: Contested spaces: Bridging protection and development in a globalizing world. June 19-22, Umeå, Sweden.
6. 2016ME320B ("Mining in Maine: Exploring Public Perceptions") - Dissertations - Morgan, Andrew. 2017. Risk Perceptions of Metallic Mineral Mining in Maine. M.S. Thesis. School of Forest Resources, University of Maine, Orono, ME.